RB Crowell

# INSECTICIDES, FUNGICIDES, AND WEED KILLERS

# INSECTICIDES, FUNGICIDES, AND WEED KILLERS

A PRACTICAL MANUAL ON THE DISEASES OF
PLANTS AND THEIR REMEDIES, FOR THE USE OF
MANUFACTURING CHEMISTS, AGRICULTURISTS,
ARBORICULTURISTS AND HORTICULTURISTS

BY
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TRANSLATED FROM THE FRENCH AND ADAPTED
TO BRITISH STANDARDS AND PRACTICE

*SECOND ENGLISH EDITION, REVISED AND ENLARGED*
BY
THOMAS R. BURTON

WITH EIGHTY-FOUR TABLES AND THIRTEEN ILLUSTRATIONS

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# AUTHOR'S PREFACE TO FIRST EDITION

Every year the diseases of plants become more numerous, their economic importance increases, and the number of those interested becomes greater; more numerous by the means of communication established between different countries, and by more frequent commercial intercourse; more important and more dangerous because they prevent the heavy yields of different crops which should be obtained from the high farming with which the prosperity of our farmers is so closely associated; the number of those interested increases because gardening for pleasure, ornamental horticulture, extends daily more and more amongst all classes of society. It therefore becomes indispensable that the farmer, the gardener, and the amateur flower grower should possess a treatise in which they can easily find the cause of the diseases which dishearten them, and at the same time an efficient remedy capable of circumscribing them and of preventing their return.

So as to render this treatise complete in itself it was deemed necessary to pass in review the numerous experiments made up to now to suppress and prevent plant diseases.

The author has striven from the aggregate of the results reported to frame certain scientific rules which appear to determine the success of certain classical methods and to explain certain notorious failures, rules which may serve as a useful guide to future experiment and aid in the discovery of new products of greater efficiency than those now at our disposal.

The preventive and combative treatment of the diseases of plants requires a profound knowledge of the parasite as well as the product used as a remedy. Success depends on the judicious choice of the remedy utilized and the manner in which it is applied.

E. BOURCART.

Paris, 1911.

# REVISER'S PREFACE TO THE SECOND ENGLISH EDITION

Dr. Bourcart has done his work so well that the translator would fail in his duty if he did not insist on one point on which the author is silent, *viz.*, the enormous value of the great number of tried recipes—recipes which have passed the ordeal of a capable and wise censorship—embodied in this treatise to every one interested, whether farmer, gardener, forester or last but possibly not least the manufacturing chemist.

The years which have elapsed since this work was first translated have been characterized by considerable developments in the application of chemical science to agriculture. The study of insect and other pests and the means for their suppression have been actively pursued; and, particularly, it has been sought to turn to account the knowledge of toxic chemicals derived from war-time investigations. Much of the work, however, has not got beyond the experimental stage; and it is necessary to proceed with caution, as too drastic measures may result in destroying beneficial as well as harmful organisms. In preparing this reprint, therefore, although, in part, fresh matter has been substituted for older, historical sections, the broad basis of the original work has been retained. Where new methods and recipes are given they are those which have been thoroughly tested and generally bear the stamp of official recommendation. Particularly extensive developments of the insecticide industry have taken place in the U.S.A., often along different lines as regards procedure and nomenclature from those followed in Europe. The huge geographical area of the United States, with its extensive tracts of swamp, lake, and forest, and generally mild and humid climate bordering in parts on the sub-tropical, favours the production of a rich entomological fauna which, however interesting it may be to the scientist, is certainly full of perplexities for the farmer. So we find a multitude of liquids and powders devised for destroying insect pests with active assistance and supervision from a paternal Government to regulate their use or abuse. The research work in the British Empire and European countries and their colonies is considerable, and is rapidly growing in importance as the regions of cultivation are extended, especially in the tropics and the warmer temperate zones. Due cognisance has been taken of these developments, but this book in its revised form remains an English translation of a French work based on fundamental principles and supported by the proofs of experience.

The entomological glossary, formerly a separate section, has now been incorporated in the body of the book, chiefly in the form of foot-notes.

T. R. B.

8 Broadway,
Ludgate, London, E.C.4.
*September* 1925.

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# INSECTICIDES, FUNGICIDES AND WEED KILLERS

## INTRODUCTION

**Relative and Absolute Diseases.**—Plants, like man and animals, in virtue of their living cellular constitution, are liable to disturbances of their physiological equilibrium, that is, to diseases. The diseases of plants are quite as well defined as those of animals, and a certain analogy exists between them, so also with the inducing causes. We again find amongst these causes the same physical, chemical, or parasitic elements. These causes generally co-operate to produce disease; but one cause is always preponderant and serves as a basis for classification. Plant diseases are divided into (*a*) *relative* and (*b*) *absolute* diseases. Relative diseases are a return to the natural wild state of the plants artificially selected and profoundly modified by man, and so it is that Brussels sprouts, turnip cabbage, and the different species of cauliflower are derived from a species of cabbage to which a disease, *Parenchymatosis*, has been imparted artificially by over-nitrogenous feeding systematically pursued for several generations. The tendency of these plants to form large fleshy buttons, in the form of a cabbage-head, or excrescence of the stem, is not at all inherent in the species, and it is not unusual in dry seasons to observe a return of these plants to the primitive condition. This degeneration is regarded as a *relative disease.* It is the same with fruit trees; we skilfully maintain by pruning the morbid condition which forces them to produce an exaggerated amount of fruit so as to accomplish in this way the end which we assigned to them. Their return to the natural state is regarded as a degeneration or a *relative disease. Absolute* diseases result, on the other hand, from more or less profound alteration, general or local, of the organs of the plant; from a more or less extensive and complete alteration of the cellular tissue. It is to *absolute* diseases alone that the etiological observations which are about to be examined apply.

**Etiology.**—Etiology is that part of pathology which is concerned with the research of the origin of diseases, and examines the causes which induce them. The latter are divided into *effective* causes (those which actually cause the disease) and *adjuvant* (helping, predisposing) causes (those which place the plant organism in such a condition that the effective causes can act). In practice, these causes are confused and linked together in such a way that an adjuvant cause in a given disease may become an effective cause in another disease. It has been seen that the etiological factors of disease may be divided into (1) physical, (2) chemical, and (3) parasitic.

(1) **Physical Causes.**—These depend on climate and season. Heat, cold, drought, and humidity, more or less sunlight, are factors which greatly influence plant growth. They cause deadly plant diseases when all favourable conditions do not work together. Here, as in the animal kingdom, the great law of selection intervenes. Only plants able to live in the existing climatic conditions will subsist, the others suffer, fall ill, and disappear. There are few remedies for climatic causes.

(2) **Chemical Causes.**—These relate, especially, to the chemical composition of the soil, from which the plant draws the elements required for life and growth. These may exist too abundantly, or not in sufficient amount. These physical and chemical causes favour the development of parasitic diseases. Plants weakened by these causes can exert little or no cellular resistance to being overrun by parasites, which find in them a medium favourable to their growth and development, for however unfavourable these conditions may be to the development of the plant, they are precisely those which favour the evolution and multiplication of parasites.

(3) **Parasitic Causes.**—The evolution of all parasites, animal or vegetable, should be well known, as they are neither injurious nor destructive to the same extent in different phases of that evolution. Each parasite has a very characteristic evolution, more or less long, always the same for the same species. (1) *Animal Parasites.*—These belong to the most diverse classes, but insects especially occasion the most frequent and perceptible damage. The insect originates in the egg. The insect which it contains passes through very different conditions, until after a greater or less length of time it becomes perfect, that is, capable of laying eggs to ensure its reproduction. The sequence of these intermediate conditions is called metamorphosis, and the different forms, larvæ, caterpillars, grubs, chrysalides, etc. It is especially in the larva form that the insect is most injurious. A sound knowledge of these metamorphoses, of the periods at which they take place, and the spots where they occur will render the struggle against insects at the moment of their evolution—when they are the most sensitive to insecticides and when they cannot withstand their energetic action –comparatively easy. (2) *Vegetable Parasites.*—These include fungi and certain phanerogams. Fungi have also an evolution, differing greatly with the species, and often very complex. Their method of reproduction, the time and place where the spores are produced as well as the plants on which these spores can germinate, should be known. The reproduction of fungi is effected by means of spores. These spores develop when climatic conditions permitting their evolution are realized. The *mycelium* (this is the name given to the new-born parasite) can then expand, either in the interior or on the exterior of the plant which they attack. In both cases it lives at the expense of the cellular tissue, and in so doing produces characteristic diseases. Organs of reproduction are formed on the mycelium, from which spores that spread the disease are detached. The

spores produced differ with the season and locality of the plant. They are differentiated into (1) summer spores, very delicate, which generally produce a mycelium forthwith, and (2) winter spores, very hardy, which do not develop until after a winter passed as such. No general rule can be given as to the evolution of fungi. It differs as much from one species to another as in that of insects. Species exist of very complex forms, the evolution of which obliges them to pass each cycle on very different species of plants. The suppression of one of these plants in the district may lead to an instantaneous and complete stoppage of the disease. These fungi are not all equally injurious. The following classification, based on their action on plants, has been adopted: (*a*) *Absolute parasites*, (*b*) *Wound or weakness parasites*, and (*c*) *Facultative parasites*. (*a*) The first, the most dangerous, are capable of attacking healthy plants. (*b*) The second can only attack the plant if its physiological condition is abnormal, *i.e.*, attacked by disease, if its *vital* energy be diminished by climatic conditions; or if hail, or frost, grub, or other cause has made an opening in the epidermis, enabling them to penetrate into the interior. (*c*) The third are the fungi formerly termed saprophytic fungi as opposed to parasitic fungi. Whilst the latter draw their nutriment from the living cell, the former live on inanimate organic matter. It has been ascertained, nevertheless, from the profound study of cryptogamic diseases that saprophytic fungi may, in most instances, become dangerous parasites if, through special circumstances, the plant cell may happen to contain elements sought after by one of these fungi. Thus the *Penicillium glaucum*, the well-known green mould, which usually grows on an inanimate medium, is attracted during the ripening of fruit by the sugar contained in the latter, and penetrating therein causes them to rot. (3) *Microbe Parasites.*—In the case of a microbe parasite it is especially necessary to know what factors induce its development, which is closely connected with the composition of the cellular substance, the temperature, and the moisture. Plants, however, suffer less from these than animals, because the reactions of vegetable plasma are acid, which are less favourable to their evolution than an alkaline medium. However, the daily discovery of parasitic microbes helps to throw light on some of the morbid phenomena of plants, and microbes appear to play a most important rôle in plant pathology.

The antagonism between animate beings, as much animal as vegetable, which live in the same medium does not give rise solely to very weak, morbid conditions, but also to relations between beings of very different species, which are advantageous to the two antagonists. These associations are termed *symbioses*. De Bary, generalizing the term *symbiosis*, distinguished (1) *Mutualistic symbiosis* or advantageous co-operation of the two associates, and (2) *Antagonistic symbiosis*, where the one lives at the expense of the other.

**1. Mutualistic Symbiosis.**—Many cases of evident symbiosis occur between phanerogams and cryptogams, between cryptogams and microbes, and between phanerogams and microbes. Amongst these symbiotic associations the lichens must be regarded as the most typical and the most perfect example. It is the most complete association known, where the elements, fungus, and alga are so closely associated that henceforth it is impossible for them to live apart. The most interesting cases are those of evident symbiosis between certain fungi and trees such as *Fagus* (beech), *Corylus* (hazel), *Castanea* (chestnut), and several species of *Coniferæ*. In this symbiosis, known as *Mycorrhiza*, the *mycelium* of the fungus invades the roots of the tree, and, whilst borrowing the necessary elements of life from the tissues of the plant, cedes to it the nutritive elements favourable to its growth. Other symbioses of great importance to agriculture exist between certain cultivated plants and certain microbes. We have, on the one hand, the *Bacteriorrhiza* of Hiltner and Strömer, in which bacteria, whilst drawing their nutriment from the cells of the root epidermis of *Beta* (beet) and *Pisum* (pea), without injuring the latter prevent injurious fungi, such as *Phoma* and others, from invading and destroying these plants. Again, microbes and *Leguminosæ* are associated together: *Rhizobium leguminosarum* (Frank) and *Bacillus radicola* (Beijerinck). These bacteria live on the excrescences, the characteristic nodosities which they produce on the roots of the *Leguminosæ*. If they draw the necessary elements of life from the cellular tissue of the root, they as a matter of compensation cede to the nursing plant nitrogen of the air in an assimilable form. These symbioses are favourable to the development of the plant, and the rupture of this association necessarily creates a less prosperous state, more akin to a grave pathological condition; the more complete the symbiosis the more the health of the plant depends on the nutritive elements with which these associates are capable of supplying it. In the disinfection of the soil by chemical agents it sometimes happens that, in destroying noxious parasites, the mutualistic parasites are destroyed at the same time, and that in curing one disease another is created. Pure cultures of these useful bacteria, or of the mycelium of mutualistic fungi, must, therefore, be spread on the fields some time after disinfection. The very contradictory results obtained on the large scale by the use of pure bacteria arise from the fact that these should be applied, not upon *any* soil, but on *a* soil disinfected by carbon disulphide. The soil is like a wort, and there is a great analogy between selected leavens (yeasts) and soil bacteria. The selected leavens cannot yield a result except on wort previously freed—by sterilization, by means of heat—from any other leaven which would hinder their development. In the same way, the soil which it is desired to sow with mutualistic bacteria should be freed, by previous disinfection, from the elements which can, by their presence, oppose the normal evolution of these useful bacteria. Each plant possesses its own bacteria, and in each particular case requires the aid of a pure, selected, and well-defined culture of microbes.

**2. Antagonistic Symbiosis.**—The most common result of the antagonism between animated beings is the parasitic disease—general or local—to which the plant, badly equipped, or in bad condition to resist the attack of its enemies, succumbs. The number of plant parasites is immense, and they are found in all classes of animated beings (phanerogams, cryptogams, bacteria) as well as animals (worms, insects, acari) living at the expense of the plant. They all become more dangerous, the one more than the other, in so far as they find the medium favourable to their development and extraordinary multiplication—a medium of constant and invariable composition, and climatic conditions lying between narrow limits, to which are intimately linked the growth and reproduction of each organism. Between enemies the struggle is constant. The reaction of the plant against the parasites which threaten it, its cellular activity, which opposes to them its layers of bark which creates deposits of tannin, of acids in the cells, layers of wax on the epidermis, prevents it from succumbing. There is no disease until the reactive forces of the plant become powerless to prevent the development of parasites, until the disposition of the subject, and special and exceptional conditions, facilitate their evolution, increasing their virulence and their number. There is, however, disease when the parasitic antagonists imported from a foreign country (as was the case with certain insects imported from America, and as is seen in America as regards insects of European origin) are deprived of their natural parasites capable of hindering their abnormal multiplication. Great invasions of parasites must be regarded, in fact, as accidents, for nature has attached to each ravager one or more parasites which live at its expense, just as it itself lives at the expense of the plant. These parasites obey the same laws as the ravagers, multiply with the same rapidity as the latter, and by diminishing their number form the check which nature opposes to the abnormal multiplication of the species. Moreover, sudden changes of temperature at the time of the casting of the skin of the larvæ of the insects —then very delicate—frosts, heavy rain, free electricity, appear to be some of the causes which hinder the development of too great a number of parasites. In nature these causes prevent epidemics, which would be very rare if man did not, by his methods of culture, create specially favourable conditions for the evolution and multiplication of parasites. Formerly, this state of affairs was remedied by the bare fallow; to-day, rotations are preferred; to-morrow, the annual disinfection of the soil by means of carbon disulphide, that of the underground and aerial (above ground) parts of plants by insecticides and anticryptogams may definitely abolish a condition which necessarily results from our methods of cropping. It will be seen, however, that the complete destruction of parasites is not indispensable, but even injurious, and that disinfection should only re-establish equilibrium, a *modus vivendi* between the plant and its parasites. It is necessary, in fact, to avoid diminishing in the plant the reactive force of the cells, so that these may always be armed and active, and able at any moment to sustain the struggle against parasites. This equilibrating disinfection is realized in the protection of the vine against *Phylloxera*[1] and cryptogamic parasites by the annual treatment (*a*) of the soil by weak applications of carbon disulphide, of dissolved sulphocarbonate, and (*b*) the aerial or above-ground parts of plants by sulphuring, multiple spraying with weak cupric bouillies, washing of the stock with ferrous sulphate (green vitriol), and by scalding or hot water treatment. The number of plant diseases increases, as now we do not solely cultivate native plants, but more and more foreign species imported into the country. The deportation of the latter places them in new conditions against which nature has not armed them; and in the country of their exile they are defenceless against parasites. But these plants import parasites which find a favourable medium for their evolution in the plants of their new country, against which the latter are not armed.

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[1] Phylloxera of the Vine. *Phylloxera vastatrix* (aerial and subterranean). —The adult female lays a single egg on the wood of the aerial part of the vine called a winter egg. The young apterous phylloxera which issues from it either immediately gains the roots or the leaves of the vine, on which it produces a characteristic gall doing little injury to the plant. This aerial form or gallicole of the phylloxera is rarely found on French vines, but it is very widely spread on American vines, the roots of which are not generally invaded by the insect. The aerial form of the phylloxera does not belong to the indispensable cycle of the very curious evolution of this insect. The young phylloxeras which descend to the roots prefer to fix on the radicles to introduce their dart there and to remain fixed at the same spot, continually sucking the juice of the plant.

**Therapeutics.**—Therapeutics is that part of medicine which treats of curative agents and studies the manner of using them in the treatment of disease. *Vegetable therapeutics* is based on physiological data on the knowledge of the physico-chemical properties of curative agents, on their action (1) on the plants to be treated, (2) on the factors which cause the disease. It will therefore be necessary to indicate in the case of each chemical product used in the treatment of plant diseases (1) the process of manufacture of the chemical product. (2) Its physico-chemical properties, a knowledge of which facilitates the preparation of therapeutic specialities and makes known their mode of action. (3) Its use in human medicine. (4) Its action on the plants treated. (5) Its action on the parasites to be overcome, or on the factors injurious to plants. Curative treatment is *surgical* when the effective causes are suppressed without the aid of chemical products, and *chemical* when recourse is had to the aid of chemical products. The use of the one does not exclude the use of the other, and the two utilized simultaneously may produce a better effect.

**Surgical Treatment.**—Surgery, or operatory medicine, is the part of medicine which comprises the intervention of the *naked* hand or the hand *armed with instruments*. The intervention of the hand armed with instruments has given rise to vegetable surgery, the intervention of the naked hand to the *methods of destruction of parasites*—picking, collecting, trapping, baiting.

**Vegetable Surgery.**—Vegetable surgery has many analogies with animal surgery. An organ deeply attacked or capable of being regarded as a seat of infection should be removed in either case. That is so much the more easy in the case of a plant, as the latter is a being whose growth, by budding, is indefinite, and that the organs removed are replaced by equivalent organs in a comparatively short time. The best known process, called "phloioplasty," consists in removing in a partial or general way the old bark from the trunk and large branches of a diseased tree as far as the liber. The dressing of the wounds, which ought to be kept as clean as those of man, is done thus: If the disease be so deep seated as to necessitate exposing the wood, a protective coating, after cleaning, is spread on the surface of the wood, which preserves the wound from contact with the air, but if there be a living piece of bark (parenchyma, cortical fibres, or liber), whether in the heart of the wood or on its edges, it must be respected and protected by some folds of the suberose layer. In this latter case, the application of a coat of tar would be fatal, especially if used hot. The artificial wound method is practised to restore health to a tree whose bark is invaded by *scolytus*. Longitudinal incisions are made on the parts attacked, penetrating the cortical layers only as far as the liber. In serious cases, a narrow band is removed from the suberose layers. This superficial incision induces a flow of sap, leads to the formation of new tissue, and stops the transversal progress of the larvæ of the *scolytus*. If the tree has been invaded in all parts by scolytes, the great part or even the whole of the circumference of the tree is decorticated but so as not to wound living tissue. When the strips are removed, hems are formed; when the tree is completely decorticated, a network of cortical fibres is seen to form on the surface, the diameter of the tree grows, and a new bark is formed. Surgical interventions of this kind, although rarely employed, may be useful when chemical treatment has no effect.

**Methods of Destroying Parasites by the Naked Hand.**—When a parasite is of appreciable size, and especially when it forms visible and accessible colonies, its suppression by catching gives immediate results. On a large scale the parasites may be induced to localize themselves in spots where their destruction is easy. According to circumstances the methods used are (1) Picking or catching, (2) Traps or baits.

**Picking and Catching.**—Coleopterous insects (cockchafers), grubs of butterflies, especially when they live in colonies, the agglomeration of eggs of certain Bombyx [1] (Ocneria) are picked. This picking is generally done by hand. However, when it is desired to pick small insects rapidly, tinned iron funnels with a wide mouth are used, above which the infected organs of the plants are shaken. The neck of the funnel is connected with a cloth sack into which the parasites fall. The destruction of insects on farm land is also accomplished by aid of poultry. For this purpose there are portable hen-houses, which are drawn into the middle of the fields. The poultry wandering about at will soon free the plants and the soil from parasitic insects. It is a very cheap, useful and ready method at certain times of the year.

**Traps and Baits.**—To facilitate the collection of insects and their larvæ artificial shelters fixed on the plants have been tried. The trunks of trees in autumn have been girdled half-way up with undulating cardboard bands of about four inches wide or with bands of straw. All the insects which hibernate as perfect insects take refuge there. All that has to be done is to remove and burn the refuges. This process is of frequent use in Germany to destroy the vermin of fruit trees.

Traps fulfil the same purpose as shelters, they draw the insects to a certain point and render them more accessible for destruction. When a polyphagous (omnivorous) insect has a marked predilection for a plant, trap-plants are sown between the lines of the crop. The insects prefer to seek the trap-plant, on which it is easy to collect them or destroy them by energetic chemical means, destroying both the insects and the trap-plant at the same time. The larvæ which ravage the plants in the soil may be destroyed by analogous methods. Fleshy roots or tubers are buried in the soil between the rows of the cultivated plant which are removed when the parasites have chosen a domicile there. *Nematodes* [1] and grey worms, which are polyphagous but have a marked predilection for certain tubers, are destroyed in this way.[2] Lantern-traps are used to destroy winged nocturnal parasites, butterflies, and coleoptera. They form luminous fires which attract the moths at night. Acetylene lamps fitted with a reflector and surrounded with a plate coated with birdlime retain the nocturnal visitors. This process is used in viticulture in which it helps to lessen the Pyralis [3] and the Cochylis.[4] Therapeutical surgery is therefore chiefly used to combat animal parasites.

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[1] Bombycides.—Nocturnal moths, heavy and squat in shape, with a body abundantly covered with hair; the wings are at rest, sloped like a roof. The caterpillars almost always bristle with numerous long hairs; they spin cocoons to transform themselves into chrysalides.

**Beneficial Insects and Parasites.**—One means of destroying pests is by the encouragement of organisms which prey upon them. This branch of research is being vigorously followed and in many cases has met with a considerable amount of success. To quote a single case, which could be multiplied indefinitely, the Pentatomid, *Perillus claudus*, is one of the most important predaceous enemies of the Colorado potato beetle (*Leptinotarsa decemlineata*) in its original home, about the eastern foothills of the Rocky Mountains, and has gradually spread eastward with it. For the last twenty years this bug has kept *L. decemlineata* in check in Michigan; the arsenical sprays used to control the beetle do not destroy the bug. Care needs to be exercised, however, in displacing the "balance of Nature," as unexpected results sometimes follow. A case is recorded, for instance, in which a colony of *Coccus* (*Lecanium*) *hesperidum*, L., on oleander was destroyed by the Chalcid parasite, *Coccophagus scutellaris*, Dalm. Subsequently the dead scales provided a breeding-place for the more harmful species, *Pseudococcus adonidum*, L., which otherwise could not have obtained on the smooth leaves the refuge it always needs. However, useful parasites now run insecticides close and at any rate constitute a powerful second line of defence. Ichneumon flies are chief among the beneficial insects in agriculture and gardening, and there are several thousand British species of these insects. The *Aphidius* ichneumon attacks the aphides which infest corn ears, while the cabbage ichneumon fly keeps down the number of cabbage white butterflies. The larvæ of these butterflies devastate crops of cabbages and other green vegetables and the ichneumon fly lays from 20 to 50 eggs in one caterpillar—and the ichneumon grubs after feeding on and killing the caterpillar emerge and spin small yellow cocoons on the cabbage leaves during the summer, and on a wall or fence in the autumn. Fig. 1 shows three clusters of these cocoons photographed to the natural size, and whenever cocoons of this description are found they should be left undisturbed or preserved carefully—as ichneumon flies form the best protection for vegetable and garden crops.

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[1] NEMATODES or eel worms are small worms of a filiform aspect, a smooth tegument, which live in the interior of plant-tissue, causing characteristic deformations of the organs attacked.

[2] *Translator's Note.*—As many as 150 wire-worms have been trapped by rape cake, etc., 2—3 inches underground close to one hop hill by Whitehead.

[3] PYRALIS OF THE VINE.—Tortrix, 1 centimetre long, of a more or less gilt yellow. The eggs hatch in the end of August. The caterpillars hibernate between the fissures of the props and under the bark in a small case of white silk which they spin. In the following May they quit their cocoons and gnaw the young buds; they agglomerate the small nascent leaves with silk thread, thus preventing the buds from expanding; moreover, they encircle the small grapes with a silky envelope inside which they shelter.

[4] COCHYLIS AMBIGNELLA (cochylis of the vine, the vine tortrix).—This small tortrix is about half the size of the pyralis of the vine, its length is 8 millimetres. The upper wings are yellowed, crossed by a wide brown band. The under wings are grey. Two generations annually. The caterpillars of the first generation invade in May the young vine shoots of the vine in flower, of which they eat all the parts; the vine shoots which escape in the spring are afterwards attacked by the caterpillars of the second generation which invade the shoots at the time the grape ripens.

In English gardens growers of green vegetables suffer from the ravages of the larvæ of the cabbage butterflies. The best remedy is hand picking, but, fortunately, their number is kept down by ichneumon flies, which lay their eggs in the bodies of the caterpillars, which die after providing food for the larvæ of these flies. When batches of yellow or white, silky cocoons as illustrated are found on walls, fences or plants they should be carefully protected—as these cocoons are of great value to the vegetable grower. Other beneficial insects in England are hover flies, lacewing flies, and ladybird beetles.

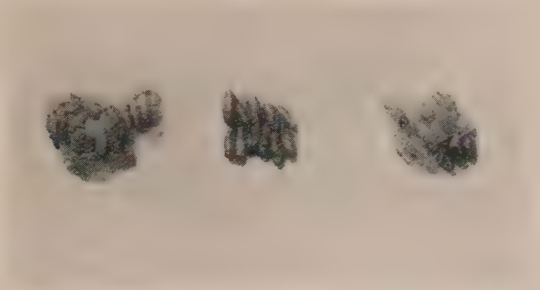

Fig. 1.—Three batches of Cocoons of the Ichneumon Fly which should be protected.

**Chemical Treatment.**—Cryptogamic diseases require chemical treatment, for it is a case of overcoming organisms so infinitely little that the eye can often only see them with difficulty.

**Curative Treatment.**—The chemical treatment consists in placing the parasites in contact with substances which have an injurious effect on them.

**Insecticides** are used to kill insects; *anticryptogamics* or *fungicides* to combat parasitic fungi. To get the best results from the use of chemical reagents, it is desirable to know the properties of the curative agents and the right method of using them.

**Examination of Curative Agents.**—The chemical products utilized in the struggle against parasites ought to respond to the following different requirements: (1) To destroy the parasite or arrest its evolution. (2) To be more poisonous to the parasite than to the plant.

(3) To preserve their poisonous properties for a certain time and to adhere sufficiently to the organ of the plant. (4) To enter into intimate contact with the parasites or their elements of propagation.

**Action of Chemical Products on Parasites.**—Most of the chemical agents employed against parasites act chemically on their vital substance. The most active are in general those which form inert derivatives with it, which precipitate the albumen or which modify the plasma; such are corrosive sublimate, formol, copper salts, phenols, etc. They thus arrest, temporarily or definitely, the evolution of parasites or their elements of propagation. In the case of bacteria the phenomena of destruction may be more easily observed. It is then observed that their evolution and reproduction are arrested by the formation of an inert layer around them. It suffices often by prolonged washing of these bacteria with appropriate liquids to remove the immobilizing layer and to allow them to resume under normal conditions the sequence of their uninterrupted evolution. The chemical agents do not therefore necessarily kill the parasites and their organs of propagation; often they only paralyse for a certain time the normal evolution of the parasite. The more the therapeutic agent is capable of insolubilizing albumen, or of modifying the substances constituting the cells, the more active it is. Wuthrich examined the comparative action of various substances on the different spores of fungi. His researches, in which mention is made of the relation which exists between the molecular weight of the chemical products and their action on parasites, leave no room for doubt on the subject of the similarity of the action of various chemical products on the vital substances of parasites. Other poisonous chemical products act on parasites, some in virtue of their properties as solvents of organic matter, such as the caustic alkalies, alkaline soaps in aqueous or alcoholic solution, and certain acids, others by their dehydrating action exerted chiefly on the medium on which the parasite lives. No parasite living in an aqueous medium can develop except when the amount of water contained therein does not descend below a minimum. A disease may be stopped if the conditions of existence of a parasite be modified in this direction. Other chemical products are *asphyxiants :* impalpable powders, and oils and fats; they obstruct the respiratory passages.

**Action of Chemical Products on Plants.**—The chemical products used to combat plant diseases have all, to a certain extent unless insoluble, an injurious action on plants. The plant is generally less sensitive to chemical agents than the spores of fungi, and more sensitive than insects, their larvæ, and their eggs.

**Liquids Spread on the Surface of Plants** may penetrate therein by *endosmosis*, whilst gases and vapours do not appear to be, or are with difficulty, absorbed by the plant.

It follows that the treatment of plant diseases may be preferably done—

1. *By products under the form of gas or vapour.*
2. *At a time when the organs which permit endosmosis no longer exist, and when the cellular activity of the plant is reduced to a minimum, that is to say, in winter.*

At that time of the year chemical agents of any degree of concentration may be used without injuring the plant, whilst in summer infinite precautions must be taken not to destroy the organs of the infected plant at the same time as the parasites. Treatment by gas is very efficient, and is becoming more common every day, whether it be the treatment of the part of the plant above ground (aerial), or of that underground, the roots being infected as frequently as the stems by parasites injurious to their normal evolution. With this end in view injections of carbon disulphide, petroleum, benzene are made into the soil, and by enclosing (*clochage*) the part above ground, an atmosphere may be created charged with sulphurous acid, carbon disulphide, prussic acid, nicotine, etc. When solutions or emulsions of the chemical agents are to be used in spring and in summer, the sensitiveness of the plant towards these ingredients must be known. Each plant possesses its own particular sensitiveness towards substances poisonous to parasites, and it is desirable to use these substances, in each instance in an appropriate degree of concentration. When the sensitiveness of the plant is greater than that of the parasite, there is reason to abstain from the use of such substances, or it is then necessary to follow the spraying by washing with pure water, only giving them the time required to act on the parasite. This latter precaution allows the use of strong doses of toxic substances, doses which would kill the plants if the washing did not intervene to prevent prolonged contact.

**Indispensable Properties of the Chemical Agents.**—The chemical agents should be of such a nature as to guarantee reaching the parasites. Certain insects and their larvæ are covered with hair and down, or even with a coat of wax, which prevents aqueous solutions from reaching them. The insecticides which should be employed in such cases are alcoholic, ethereal, or oily solutions, soaps and caustic alkalies having a solvent action on the organs of protection, and capable of moistening them, so as to let the toxic substances penetrate as far as the sensitive organs of the insect. The treatment should often be curative and preservative, and it is then necessary that the substances used should persist for the longest time possible on the surface of the plant. This problem would be easily realized if rain did not remove in a short time the deposit of substances created by spraying. Attempts have been made to protect plants from the effects of the natural washing by the use of substances of poor solubility in water, and with a perfect adherence to the organs of the surface treated. The agents only slightly soluble in water spread on the surface of the plant, in the form of *bouillies*, form deposits which the rain cannot remove owing to their own adherence, or to an adherence acquired artificially, by the incorporation of gluey substances, insoluble in water (silicate of soda, saccharates, soaps, gelatine, rosin). But care must be taken not to use too insoluble substances and in too great quantity, for there is a risk of covering the whole of the respiratory surface of the leaves with a layer rendering the exchange of gases impossible, which, if it does not cause asphyxia, produces at least an annoying disturbance in the growth (evolution). The insoluble, or the only slightly soluble products are, in general, of greater service than the soluble products.

In addition to their less injurious action on the plant, they persist longer on the surface of the vulnerable organs and their action is of longer duration.

The insoluble products are intended to poison insects through the stomach. A slight layer of arseniate of lead, or of arsenite of copper (Paris green),[1] on the leaves penetrates into the stomach at the same time as the leaf and kills the insect. In the case of cryptogamic parasites, slightly soluble substances are used, which in contact with the dew causes it to become toxic, owing to the traces of poison which it has dissolved, and to kill the spores, which require its aid for their evolution. Briefly, it is necessary in each particular case to choose the appropriate remedy and to use it with discretion. It is the most difficult side of vegetable therapeutics. The therapeutic store contains a great number of products the action of which is analogous. Those which can be usefully employed can be reduced to a small number. The most interesting are carbon disulphide, Bordeaux bouillie,[2] lime, sulphur, sulphate of iron, sulphuric acid, emerald green, soap-emulsions of petroleum and alcohol, tar, prussic acid, nicotine, and nitrobenzene. The greater number of the chemical products which have been the subject of experiment against the diseases of plants are, nevertheless, dealt with in this treatise, and deductions drawn from the aggregate of the results obtained by the experimenters. The results which have been published are so very different, and the opinions expressed so contradictory, that the author has been obliged to control the facts by personal experiment before expressing an opinion. Laboratory experiments do not always permit of the conclusion that their results will be confirmed in actual practice; parasites have natural means of protection which are awanting in the laboratory, but which enable them in a natural state to escape very often from the deadly action of the agents used. Experiments, therefore, to which most weight is attached are those made in practice. According to their mode of action and their nature, chemical agents are used and applied in very different ways.

**Methods of Using Chemical Products in Treating the Diseases of Plants.**—Insecticides and anticryptogams are used in three forms: (1) As gas. (2) As powder. (3) In the state of solution or suspension in a liquid vehicle. *Use of Chemical Agents in State of Gas.*—Gases are used in closed spaces under a *cloche*[3] or in the soil. For this purpose there is utilized either liquids which evaporate at the ordinary temperature or solid products which disengage gas by heat, combustion, or chemical decomposition. In any case it is necessary that the gas mix perfectly with air and reach all the corners of the area to be disinfected. In closed spaces that is comparatively easy, in the soil it is more difficult to realize.

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[1] *Note by Translator.*—Arsenite of copper is not Paris green but Scheele's green. Paris green is our emerald green, the aceto-arsenite of copper.

[2] The translator has retained the French term "bouillie" throughout. The usual English rendering of the term as "Bordeaux mixture" being, in his opinion a poor rendering. All bouillies are perforce mixtures, but only a few mixtures are bouillies.

[3] *Note by Translator.*—A bell- or dome-shaped glass vessel familiar to those who dabble in the French style of gardening recently resurrected in Great Britain but well known to London market gardeners at least 150 years ago, who even in those early days used them by the hundred.

**Underground Treatment.**—Injections of volatile liquids are made in the soil at suitable depths by means of an instrument called a soil *injector* (Fig. 7), when by sprinkling the soil with water the gas which is disengaged is enclosed. When such treatment is carried out with the necessary care, so as to avoid the contact of the liquid substance with the roots of the plant it yields perfect results. But difficulties are encountered due to the nature of the soil. If it be easy to disengage toxic gases in a friable soil it becomes difficult to spread the gases uniformly in a compact wet soil. Gases circulate with difficulty through certain soils, and are not retained long enough in others. Water creates an impenetrable barrier to the circulation of gases. The gases produced in the soil should not enter into reaction therewith and be fixed by the substances in the soil. From this point of view carbon disulphide is the best substance. Other substances, such as tar, petrol, benzene, sulphuretted hydrogen, are retained by the capillarity and chemical action of the soil which often energetically opposes their distribution. To avoid failure it is well to give the preference to insecticides in dilute solutions in winter, and to volatile insecticides in summer, when the soil is dry.

**Aerial (or above ground) Treatment by Gases.**—*Clochage*, or treatment in a closed space, gives the most certain results, and does not exert an unfavourable influence on the development of the plant. Highly poisonous gases may be used against parasites, because they do not generally have a deadly action on the plant, especially when contact with the plant is not prolonged beyond measure, which result is obtained by aerating after a predetermined time.

*Clochage* is used to disinfect the vine by sulphurous acid. The stock is covered with a *cloche* made of a tun (cask) cut through the middle, or with a zinc receiver fitted with two handles. Under the *cloche* the gas is disengaged by combustion or by chemical decomposition of certain salts: sulphur is burnt, or potassium cyanide is decomposed by sulphuric acid. The operation is finished in ten minutes. In greenhouses or in closed spaces made around fruit trees or against espaliers with waterproof awning, the operation is performed in the same way. In all cases where disinfection by gas is possible, it ought to be applied as a process sure to disinfect without injuring the plant treated. It is the only process applicable to food warehouses. Treatment by gas is always curative. When this treatment is not applicable recourse is had to treatment by boiling water or solutions of toxic substances, emulsions, or pulverulent products.

**Scalding or treatment by boiling water** finds a very extended use in winter to kill by heat all parasites and their germs lodged along the trunk of a plant. But that is a winter treatment which cannot be applied in summer, the delicate organs of the plant not being able any more than the parasites to support contact with hot water.

**Use of Chemical Agents in the Form of Powder.**—Non-poisonous but asphyxiant powders are used such as they are; toxic powders are reduced more or less according to the intensity of their insecticidal or sporicidal capacity with flour, talc, chalk, or any other inert matter, finely divided and cheap. The powders are projected on to the plant by means of bellows called sulphurators (Figs. 5 and 6). Powders may be projected where liquids cannot penetrate. Liquid treatments are sometimes alternated in the struggle against stubborn diseases with pulverulent treatments of the same composition.

**Use of Chemical Products in the Liquid Form.**—Poisonous substances in a state of solution are used in both the external and internal treatment of plants. In the external treatment the poisonous substance is spread on the plant, whilst in the internal treatment it is introduced into the juice, either by causing it to be absorbed by the roots or by injecting it into the trunk. External treatment is most generally used, and it is from it that the most successful results are to be anticipated.

**External Treatment : Liquids.**—Solutions, bouillies, emulsions are much more used than gases and powders owing to their easy use. These preparations are distributed by means of spraying machines when the treatment is general, and by the brush when it is local. The efficiency of the treatment by liquids depends to a great extent on the mode of application. The substances should be projected in a finely divided state, best in the form of a mist, because it is less important to accumulate large quantities of substance in a given point than to spread a little everywhere in a uniform manner, above as well as below the leaves, on the twigs and on the trunks. The largest number of points of contact between the spores of the fungi or the insect and the poisonous solution must be secured. The appliances which attain this object are the spraying machines which have reached a high degree of perfection. The liquid preparations must possess a certain degree of concentration to be active. It is injurious to increase this concentration, and dangerous to diminish it. When a liquid preparation has a poisonous action on the plant, or if it has no adherence, these drawbacks may be obviated by multiplying the treatments with a weaker preparation. It has been found that it is better to diminish the strength of the applications and to increase the number of sprayings, for it is the abundance of these rather than the strength of the preparation which forms on all the organs, in proportion as they are developed, an extremely thin layer of a toxic substance capable of preventing the development of spores or of poisoning parasites.

Experience has proven that periodically spraying at short intervals with weak bouillies yields far better results than a single annual spraying with concentrated bouillie as formerly practised. The single spraying with a 4 per cent. copper sulphate bouillie used some years ago has been replaced by three to seven treatments with bouillies prepared with 0·5 per cent. of copper sulphate. Although the total amount of copper spread on the surface of the plant be mostly less than formerly, the result is better, because all the surface of the plant remains covered with a very thin pellicle of hydrated oxide of copper of which a trace dissolved in rain water or dew suffices, as has been found, to kill the spores which are germinated. This process is the more efficient because it especially guarantees against disease all the young organs of the plant, which being more tender and more aqueous, are more easily invaded by parasitic fungi and have therefore a greater receptivity for cryptogamic diseases. The perfection of the treatment is, therefore, an element as important to secure success as the properties of the product. When anti-cryptogamic substances are used, it is necessary to bear in mind that the external treatment of a plant cannot destroy the mycelium of the fungus which has penetrated into the plant, and its multiple ramifications in the interior of the latter are perfectly protected from all outside spraying. The external treatments are intended to destroy the organs that disseminate the disease, the conidiophores and isolated spores, and thus prevent the extension of the disease to other plants. If for any reason the treatment has been deferred and the disease has assumed a great extension, it is well to remove before spraying the parts of the plant most seriously attacked and to burn them; that is a surgical complement to the chemical treatment which may be of great service and which must not be neglected if one be anxious to suppress the disease. It is well to say that neglect of one factor may compromise the results of the treatment by liquids and rob the experimental effort of any beneficial result.

**Internal Treatment.**—From analogy, with the treatment of human diseases, attempts have been made to introduce into the sap of the plant toxic elements, intended to be carried through the plant, and to destroy the mycelium of fungi which have invaded it, or to kill xylophagic insects and those which suck the sap. The experiments of Laffitte and Henneguy have shown that a substance dissolved in water, absorbed by the roots, may ascend to the leaves and reach the extremities of the tree if it does not form insoluble compounds with the constituent elements of the sap; however, the greater number of salts yield with the plasma insoluble derivatives, which prevent their entrainment by the sap towards the part of the plant attacked by the parasites. Numerous experiments have been made in this direction to combat the phylloxera. The method used, it must be confessed with mediocre success, consisted in making a hole in the vine stock from above downwards by a gimlet, and in introducing therein the chemical agents, such as calomel, camphor, potassium sulphide. These were the first experiments carried out under very bad conditions, nevertheless carbolic acid, used by Green against lice, prussic acid against bugs, have given appreciable results. The first successful results were obtained by Mokretzki with injections of a dilute solution of sulphate of iron, and nutritive elements which he injected into the sap to cure chlorosis. These were crowned with complete success. But they must be executed in such a way that the air cannot penetrate into the wound, and a slight pressure is required to enable the liquid to enter into direct contact with the sap of the plant. However, when Mokretzki tried sulphate of copper under the same conditions, his experiments were a failure. It is possible, however, that organic salts of copper soluble in the sap may behave as indifferent salts, especially if used in small doses, and produce the satisfactory effects on the health of the tree given by dilute solutions of sulphate of iron, and by sprinkling the soil with sulphate of copper. Metals are capable of forming organic salts, which no longer precipitate albumen, and, injected into the sap, may behave in quite a different manner from the corresponding inorganic salts. These organic salts have found multiple applications in human therapeutics, and it is to be supposed that their use will extend in the domain of vegetable therapeutics. The internal treatment discovered by Mokretzki will perforce extend further when it has been determined under what form poisons can be incorporated with the sap, and especially in what degree of concentration they should be used. These remedies will form a powerful instrument against all sucker-lice, and will be capable of arresting the internal evolution of the mycelium of parasitic fungi. But vegetable therapeutics will often yield imperfect results, in spite of all the attention brought to bear in the application of appropriate remedies, for it it difficult to dislodge or to destroy in the interior and on the exterior of a plant without injuring it the parasites which develop there, surrounded by the very efficient means of protection which nature has given them; and if we insist on this axiom, that a plant disease cannot be cured, but that it can only be diminished or its extension prevented, the important rôle which preventive methods play in the struggle against plant diseases will be understood.

**Prophylaxy.**—Prophylaxy is that part of medicine which deals with the means of guaranteeing against disease and preventing it. Knowing the cause or the causes of the diseases it is possible to protect plants efficiently against them. The knowledge acquired as to the reactions of the organism, and the means by which it naturally arranges to defend itself against disease, have enabled prophylaxy to utilize physiological processes instead of agents destructive to parasites. It is necessary to differentiate between therapeutic prophylaxy and hygienic prophylaxy. The former utilizes therapeutic agents, surgical processes as well as antiseptic insecticides, fungicides. The latter employs dietetics, stimulants of growth, rational feeding, selection of vigorous and hardy species. Medicine in its application to plants is in fact as complicated as when applied to man, and it is not surprising to see it necessary to take at the same time prophylactic and therapeutic measures in order to have crops free from disease.

**Therapeutic Prophylaxy.**—When the cause of a disease is known, its evolution and that of the parasites which produce it, it is comparatively easy to find the means of checking it by preventive measures. These treatments may be very often carried out at a time when the plant can bear them with impunity; in winter when the delicate organs have disappeared and when the sap is at rest. One must never wait until a disease manifests itself, even if the possibility of its appearance is not absolutely certain. Preventive treatments if they are not always capable of removing all the effective and adjuvant causes of disease will minimize them. When the cause is a parasitic one, the object pursued is not to destroy all the parasitic elements, but to reduce them to their normal or natural number increased by our methods of cropping. In these conditions, parasites having always existed and their complete destruction being as chimerical and as useless as a complete disinfection of the air which we breathe, with the object of destroying all microbes, disease is no longer to be feared, because it no longer causes us appreciable injuries.

**Preventive Surgical Treatments.**—Operatory medicine may be of great assistance in the prevention of plant diseases; in fact the suppression of everything which may transmit a disease from one year to another is often capable of giving radical results—excision of the diseased parts, removal of branches attacked or bearing spores or eggs, washing of the bark of the trunk and branches to suppress refuges formed by mosses and lichens for acari,[1] aphides,[2] and coleoptera. Intervention by naked hand plays a rôle not less important, by the collection and suppression of the old organs of plants, leaves, and rotten and wormy fruit on which receptacles containing the spores of fungi serve as refuge to grubs and chrysalides and as shelter to masses of insect eggs. The destruction of the parasites and their hiding-places by this simple means causes them to disappear completely after a certain time.

Birdlime traps preventing insects and their larvæ from reaching points that they might ravage, are likewise useful auxiliaries. The most usual trap is the ring of tar or of birdlime with which the trunk of trees is surrounded. The going and coming of apterous parasites between the leafy portion and the soil being along the trunk, the ring of sticky substance drawn round the trunk is intended to stop these often daily journeys and to retain all these parasites stuck fast. An examination of the habits of parasites demonstrates that almost all are forced to use this road; some to seek a refuge in the soil for the night, others to ascend nightly from the soil in which they had taken refuge during the day. Thus the grub descends along the trunk to place itself as a chrysalis in the soil, and the butterfly, even when it is not apterous, ascends along the trunk to deposit the eggs which weigh down the female. The grey worm and many moth grubs go every morning to find a refuge in the soil, to re-ascend the trunk in the evening. This method, now very common, gives perfect results. In arboriculture it is a powerful auxiliary to the liming of the tree, but it is necessary to watch that this sticky substance preserves its adhesive qualities and to renew the ring when these have disappeared. Young fruit trees being sensitive and liable to perish after an application of a ring of tar or birdlime, it is well to fix round the trunk a strip of cardboard well fitted and to coat it with the sticky substance. The same result is thus obtained without injuring the health of the tree.

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[1] ACARI, MITES, or *Plant lice.*—The acari much resemble small spiders, differing, however, by their inarticulated body. Acari produce proliferations of the tissues: galls, felting, swellings, brown rust, changes in colour; leaves become yellow, red, or brown. The most injurious acari are the *Phytoptus* and the *Tetranychus* (so-called "red spider").

[2] APHIS (singular), APHIDES (plural). *Naked plant lice.*—In spite of their small size, the aphides do as much damage as large insects. They live in colonies, of which the individuals reproduce themselves increasingly during fine summer weather and give birth to a progeny of thousands. These apterous insects remain fixed on the same spot; their rostrum, planted in the most delicate part of the plant, continually sucks the juice which flows thereto. The result of this constant irritation of the cells of the plant is that it dies, or is in a diseased state, which shows itself by characteristic deformation of the organs. It will be seen that the leaves and the branches curl up, roll, swell, change colour, passing through white to yellow, to red. The plant lice secrete from their cornicles (small horns) a sort of honey-dew which they eject afar and which ends by covering the whole trees with a sticky, sugary layer preventing the respiration of the plant and attracting insects fond of this sugar. Fungi of the family of Capnodium, which live exclusively on this waste, develop there and finally cover the entire plant with their black mycelium, thus causing a disease known as *Fumagine* or smut of fruit trees.

**Grease-banding.** Grease-bands, consisting of strips of grease-proof paper about 8 inches in width, should be placed round the trunks of fruit trees early in October. The paper is tied at top and bottom with string and is coated with a sticky, non-drying substance similar to that used on fly-papers. This sticky material is to intercept the wingless females of the winter moth (*Cheimatobia brumata*) and the mottled umber moth (*Hibernia defoliaria*) which crawl up the tree trunks about the end of October or early in November to lay their eggs on the buds and twigs. The caterpillars hatch in the spring and at once eat up the young leaves and fruit blossom. The grease-bands should be renewed in February in order to catch the wingless females of the March moth (*Anisopteryx aescularia*) which ascend the trunks in the same way in March and April. As each female winter moth lays about 200 to 300 eggs, great damage can be done to the fruit blossom if they are allowed to reach the branches.

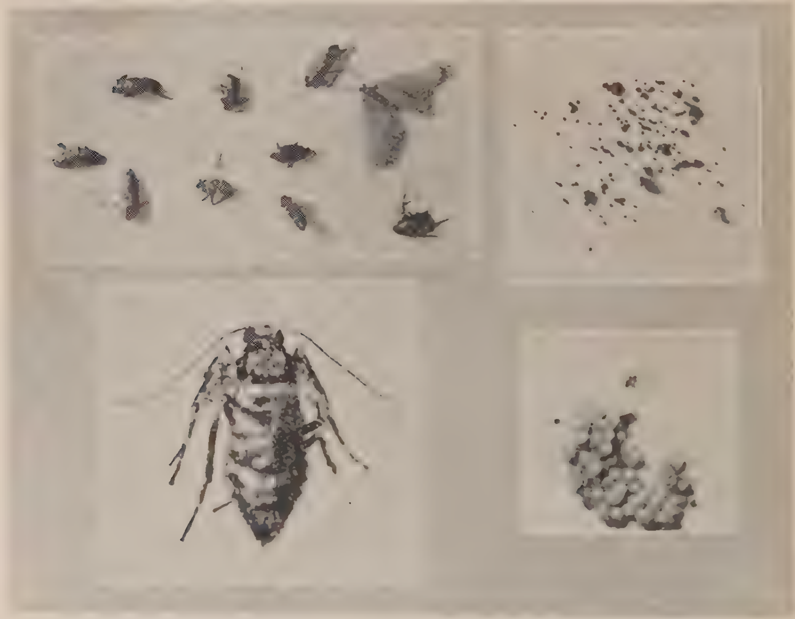

Fig. 2.—The Winter Moth.

The illustration shows several winter moths as caught on the grease-bands; a female enlarged showing the rudimentary wings; and eggs, natural size and enlarged. When laid the eggs are light green in colour, but in a few weeks' time they turn a rusty brown, and are therefore difficult to detect on the twigs and buds of the fruit trees.

**Preventive Treatment by Means of Chemical Agents.**—The general conditions as regards the properties of the chemical agents used in the preventive treatment of plant diseases are the same as in the curative treatment. The chemical products must destroy the parasites and be more poisonous to it than to the plant; they must adhere and preserve their poisonous power for a certain time, and enter into intimate contact with the parasite or with its elements of propagation. When such treatments are applied, as is often the case during the repose of vegetation, the comparative insensibility of the plant enables them to be used in doses deadly to the parasite without injuring the plant. Most fungi living protected in the interior of the tissue are sheltered from the action of the poisons spread on the surface of the organ attacked, and are evolved in spite of the curative chemical treatment. The important point in plant diseases is to destroy the spores which propagate the disease. To attain this result, different spores must be attacked by different methods. If it be a case of destroying winter spores, very energetic treatment must be applied in winter, for these spores have an extraordinary power of resisting chemical agents. If it is a case of killing summer spores, which, on the contrary, are very sensitive and delicate, a treatment with dilute anticryptogamic solutions will suffice. Preventive winter treatment can thus be distinguished from preventive summer treatment. Preventive winter treatment consists in destroying by chemical agents all parasites, and the elements of their propagation. To obtain this result the trunks and branches are painted or washed, after a mechanical dressing with milk of lime, concentrated copper bouillies, 10 per cent. solutions of sulphuric acid, hot concentrated solutions of sulphate of iron, boiling water, petroleum, and pure carbon disulphide. These chemical agents, used in such a high degree of concentration, do not injure the plant in winter, and permit of a radical destruction of the parasites. These preventive winter treatments are, generally, sufficient to prevent the diseases from appearing in the following year, especially when care is taken to destroy the decayed organs scattered around the plant, and to disinfect the soil, the dung, and the seed. This last precaution is of an undoubted utility in preventing the diseases of plants cropped annually, and the methods usually employed have now attained a great degree of perfection. Moreover, it is necessary to destroy wild plants of the same species, which are preferred by the parasites which it is desired to destroy, plants which form seats of infection which are necessary to the cyclic development of certain parasitic fungi, such as the rust of cereals, which search for nurse plants of different species necessary for their normal evolution, and the destruction of which brings about the radical suppression of the parasite. These plants are the barberry and *Boragineæ*.

**Preventive Summer Treatment.**—In spite of preventive winter treatments they must be completed by summer treatments. Working so that the vulnerable organs of the plant are always protected by a fungicide very slightly soluble in the dew, the plant is prevented from succumbing to the incessant attacks of the spores, which the atmospheric currents lead to it. It is a case of very small doses of anticryptogamic agents, which suffice when the treatment is continued during the whole period in which the disease is to be feared. Weak injections of carbon disulphide in the soil and periodic washings of the stock with dilute solutions of potassic sulpho-carbonate have given the best results in the struggle against the phylloxera, without destroying all the parasites they so far diminish their number that they can no longer injure the plant. Sulphating every year with weak bouillies yields analogous results and enables the trees to develop normally. Along with the rational and periodic use of chemical agents intended to kill the greater part of the germs of cryptogamic diseases and insects, it is well to use stimulants to furnish rational nutriment to the plants and to pay attention to their hygiene.

**Hygienic Prophylaxy.**—Vegetable therapeutics does not consist, in fact, entirely in the struggle against the effective factors, but it ought likewise to suppress the adjuvant causes. Plants are restored like animals by the art of healing regarded in its widest scope. Hygiene, which plays so great a rôle in human prophylaxy, ought to receive equal attention in the case of vegetables. This hygiene is based on a knowledge of their organs, and their mode of growth, on that of the environment where they live, and the climatic conditions which favour their development, and the mineral elements indispensable to them. It is necessary to remove bad influences from plants, and to supply them, if need be, in a regular and abundant manner with the nutritive elements which they require. If it be asserted that a disease can be transmitted to a plant by artificial infection when placed in a laboratory where it has not all its means of reaction, it must not be concluded therefrom that this same plant will always succumb to this parasite in surroundings favourable to its development and in good hygienic conditions. Owing to a special immunity which is not acquired, except under certain conditions, the plant, on the contrary, will be able to resist the attempts of invasion by the parasites and will issue victorious from any struggle in all instances.

Most cryptogamic parasites are incapable of attacking the living vigorous and healthy cell. Certain insects, even xylophagic, such as the Scolytes, only attack a sickly tree, the intense motion of the sap being injurious to the development of their larvæ. On the other hand, most parasites find an easy shelter in the plant when the latter is enfeebled by an adjuvant cause, or when organs capable of being invaded have been laid bare by a wound.

**Stimulants of Growth.**—We know the favourable influence which certain metallic salts absorbed by the sap can exercise on the health of plants. Salts of iron, copper, mercury, zinc, nickel, cobalt, manganese, lithium, fluorides, and arsenites have in a certain dose a stimulating action on the vital functions of the plant, analogous to that which arsenious acid exercises on our own organism. The use of these stimulants may often be a useful means of stimulating the vigour of the plant, and of rendering it more capable of resisting cryptogamic diseases.

**Nutrition.**—The researches of Liebig, Boussingault, Dehérain, and others have shown that the development of plants depends greatly on the mineral elements which they find in the soil, and nothing is more easy than to supply them when the soil is deficient therein. The result of these researches has been intensive farming, which by supplying in great abundance the elements necessary for the growth of plants has rendered it possible to double and triple the yield of crops. Encouraged by such success we have learned to prepare an exact account of the elements indispensable for each plant crop by the analysis of its ash, of the elements of the soil, and taking into account the nutritive elements that the preceding crop has removed and adding to the soil the elements in which it is deficient. It has been observed, however, that the plants obtained as a result of intensive manuring were more subject to diseases, and that such assumed a dangerous character. The great delicacy of the plants constituted a more favourable medium for their evolution, however little the climatic conditions favour their development, and predispose the plants to infection. It must be admitted that the intensive culture now practised does not produce a normal condition of the plant, but a cultivated condition, and that the parasites have acquired a greater vigour and become more virulent owing to the great richness of the plant in nutritive elements. Too abundant feeding of our cultivated plants has created a danger which the farmer of to-day must face.

Formerly the method of cultivation gave a mediocre and irregular yield, and the farmer did not disturb himself. Our forefathers were fatalistic as to good years and bad years. Diseases existed even then, but they were not supposed to contribute much to the annual variation in the yields. In our days they have a much more important rôle, for the cultivation expenses being higher, owing to increased attention and to the use of various chemical manures, the yield ought to compensate for the pecuniary efforts expended. It should be emphasised, however, that no amount of chemical doctoring can supply the place of efficient cultivation, though a judicious use of chemicals can help to reduce the increasingly high cost of labour.

**Exhaustion of the Soil.**—In spite of the annual supply to the soil of the elements required by the plant for its intensive growth, it is found that a time comes when the plant ceases to profit from the nutritive elements and thrives no longer. This is due to the fact that the enemies of the cultivated plant are accumulated in the soil. The alternation of crops or of different plants having consequently different parasites is now practised, and where the same plant does not appear in the rotation except at long intervals it causes a great improvement in this condition of the soil. Rotations would give perfect results in the absence of polyphagic parasites: Nematoides, Elaterides, grey and white worms which attack all our crops indifferently, and the exaggerated multiplication of which operates throughout the most different crops; the spores of *Ustilagineæ* (smut, bunt, etc.), which resist the weather for several years, excepted. Against the exhaustion of the soil from the exaggerated development of these parasites no efficient remedy exists, except disinfection of the soil by carbon disulphide. This must be done either in a complete manner, and in heavy doses every ten years, or in small doses each autumn. It frees our cultivated fields from all the parasites which our methods of cropping have allowed to accumulate in too great number. This method finds more adherents every day, as it enables rotations to be dispensed with and to cultivate the same plant intensively for several years in succession. Artificial manures as well as the metallic salts intended to stimulate the growth of plants should be used with discretion, so as not to predispose the plant by a modification of the sap to certain diseases which formerly it escaped. Laurent found that bacteria, not parasites of the potato in a normal state, might invade it after manuring with lime. The Jerusalem artichoke becomes less resistant to the *Sclerotina Libertiana* [1] after phosphatic manure. These two cases are easily explained, the first by the fact that the bacteria seek an alkaline medium created by the lime, the second by the fact that the *Sclerotina* seeks, on the contrary, an acid medium created by the acid phosphate. Intense nitrogenous manuring favours the development of phytophthora. It is thus essential to avoid the use of manures which may place the plant in a state of subjection in the struggle which it has to sustain against inimical factors.

**Choice of Species.**—One species may be more subject to disease than another, and possess a predisposition for certain pathological conditions. That occurs when the conditions favourable to the development of the plant are also those which favour the evolution of parasites at the time when the plant is young and possesses delicate tissues just when the parasites are most virulent. Care must be taken in sowing a plant that the germination of the seed does not coincide with the virulent development of the parasite, with the ripening of the spores of fungoid enemies, or the hatching of the eggs of certain insects. It suffices to sow a little earlier or later. But in spite of all that can be done to eliminate parasites, they none the less exist and ravage the tissues. The cells of the plant, like those of the human organism, react, and it is found that after this constant struggle they undergo certain modifications which are opposed to the development of the parasite, and the plant acquires a certain immunity. It is acknowledged that the deposits of tannin and other materials in certain cells and the concentration of the sap are conditions resulting from the struggle of the plant against insects, and destined to oppose an unsuitable medium to any attempt of development. Plant diseases do not, therefore, depend solely on the presence of a parasite, but as much on the conditions predisposing the plant to a want of reactive energy, and it has been found that this predisposition was an attribute of certain species or certain varieties.

**Meteorological Influences**.—Although we are still badly equipped to struggle against atmospheric influences, each day brings new discoveries from which agriculture knows how to benefit. Thus fruit blossom may be protected against frost, by means of oil-flares. Without neglecting therapeutic methods it is necessary to take incessant prophylactic measures to prevent the evolution of diseases and their propagation, to treat the seed, the plant, the soil, and the crops by toxic products, to destroy the plants invaded, which form hot-beds of infection, to avoid the importation of plants from districts notoriously infected. Effort must be made to apply a general treatment to the plant, to remove as far as possible all conditions favourable to the growth of parasites. The hygiene of the plant must receive careful attention; sowing retarded or advanced; the plants protected against eventual frosts and hail; drain and lime the soil against humidity, the great predisposing cause of cryptogamic diseases; apply appropriate strengthening manures; choose hardy species obtained by crossing or by selection, and create new varieties combining great resistance to plant diseases with the necessary properties of production. So that the struggle may be successful measures must be general. Each cultivator ought to be able to work in full knowledge of the cause; he ought to be able to obtain information on the nature of the diseases which he observes, and the means which should be used to combat them. All interested should be able to act simultaneously over a large extent of territory, a condition which will alone crown any individual effort with success.

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[1] *Note by Translator.*—Fungus which ravages potato, haricot beans, hemp, cucumbers, swedes, zinnias, petunias, chrysanthemums. *Remedy.*—Apply soot or lime to soil.

If one considers that the damages caused annually to French crops by injurious insects, according to the calculations of authorized persons, amount to several hundred million francs, and that the loss due to cryptogamic disease reaches a still higher figure, an idea can be gained of the great necessity there is to generalize the methods of struggling against parasites, and the necessity of simultaneous action by all under the control and the direction of official agents. The first order dealing with the protection of crops against injurious insects is that of the Parliament of Paris of date Feb. 4, 1732; then came the Act of the 26th Ventose Year IV, which rendered obligatory the destruction of grubs in general (modified by the Act of Dec. 24, 1888). It especially prescribes the destruction of the grubs of the Bombyx *Liparis chrysorrhea*, the brown-tailed moth, the agglomerations of which in winter and in spring form silky wrappers beween the branches of fruit trees. The Order declares that " After the date fixed by the Prefect, farmers who have not submitted to the prefectoral order, will be liable to a fine of six to fifteen francs, and obliged to pay to the administration the expenses incurred by it in grubbing on their domains." The panic created by the appearance of the phylloxera in 1863 was followed by an effect which has made itself felt in all branches of cultivation. Examination Commissions were formed, a National Agronomical Institute was founded in Paris. Chairs of Agriculture were created, new laws were passed, the Administration is working with equal solicitude at all cultural pests, and it has enacted the measures required to cope against the extension of diseases. As a consequence of the International Phylloxeric Convention held at Berne, an order of Sept. 10, 1884, interdicted the exportation and importation of rooted-up stocks and of sprouts (shoots). Then the destruction of insectivorous birds had been forbidden. Cultivators too often misconstrue their precious collaboration in the struggle against parasites.

Societies for the destruction of parasites have been formed in cantons, bureaux of gratuitous information opened, enabling interested parties to know the disease which ravages their fields, and how to prevent it, or combat it, in the most economical conditions. These syndicates are cantonal or communal; their bye-laws must have prefectoral sanction; their budget consists of the subscription of adherents, individual subscriptions, communal, and Government grants. The Council of Administration places the instruments, the insecticides, and the anticryptogamic products at the disposal of those interested; it publishes the right times to use preventive or curative processes, and gives the detail of the methods to follow; it directs itself at propitious seasons all the operations tending to the destruction of parasites, and to restore the fertility of the fields through the intermediary of an executive committee which has the direction and the responsibility of operations. Societies have been formed against the "Apple-blossom Weevil," against the may-bug (cockchafer, *Hanneton*). The annual results obtained by some may-bug societies in a year are as follows :—

| | | |
|---|---|---|
| Seine et Marne . | destroyed | 282,500 kilogrammes.[1] |
| Brie Comte Robert | ,, | 101,000 ,, |
| Aisne . . . | ,, | 13 thousand million cockchafers. |
| Bernay dans Eure | ,, | 148,500 kilogrammes. |

These figures are eloquent. However, if they show the useful intervention of the syndicates established for the destruction of injurious insects, they enable us to foresee the results that these syndicates would be capable of obtaining if their programme was a broader one, and comprised all which concerns vegetable pathogenesis, prophylaxy, and therapeutics. Common action organized in this way under wise direction will be a perfect method to combat agricultural pests and blights so long as no medical specialists for cultivated plants, with the same rank as veterinary surgeons, exist. But there is much ground to be traversed before getting so far as that: the science which should guide these medical specialists is only in its infancy, and the most important problems are still to be solved. It is, however, necessary to reach this goal so that this younger sister of medicine applied by special practitioners may render inestimable services to cultivation and increase the prosperity of the country.

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[1] *Note by Translator.*—From the peculiar style of numeration of French writers it is impossible to say whether 282.500 means 282½ kg. or 282,500 kg., that is 282½ metric tons, which seems impossible. Yet even in this country so great were the ravages of *Bombyx chrysorrhea* in 1782 that prayers were offered up in some churches for deliverance from the scourge and 1*s.* per bushel was offered for the webs, and so abundant were they in Clapham parish that 80 bushels were collected in one day in that parish alone!

# CHAPTER I

## COLD WATER—SUBMERSION—SPRAYING HOT WATER—IMMERSION—SPRAYING—HYDROGEN PEROXIDE

**Water,** $H_2O$.—Water is necessary to the plant (1) as food, (2) as solvent of nutritive matters. To a certain extent crops increase in proportion to the water used in the cultivation. Want of water injures the plant, causes deformities, anomalies, and troubles of which the chief are: *pilosis*, excess of hair on the stem and leaves, formation of tart substances (piquants), stony pears, lignification of the roots; *nanisme*, potatoes with filiform rhizomes, fall of flower-buds, premature drying of the leaves, honey-dew, barren flowers in the case of cereals. But on the other hand, if water is useful and even necessary to the plant, in excess, however, it is injurious thereto. In the latter case it is the cause of the following diseases: *frisolée* of the potato, rhytidome of the potato, germination of the same plant before potato lifting, hollow fruits, stems and roots, premature formation of seeds, dropsy, gourmands, hypertrophy of the roots, cellular rottenness, frondescence, phyllodia or chloranthia, asphyxia of the seeds and roots, putridity of the seedlings.

**Use.**—Water serves as a solvent or vehicle for most of the agents used to combat plant diseases; but it can by itself alone serve as an insecticide in many cases, and as it is cheap it is profitable to use it. Cold or hot water is used as follows, according to circumstances: *Cold water:* Submersion; spraying. *Hot water:* Immersion; spraying.

**(a) Cold Water, Submersion.**—Submersion or artificial inundation asphyxiates the insects living or refuging in the soil. It consists in placing the area of the ground to be treated under water for a period of from two to sixty days, according to the nature of the soil and the kind of parasites to be destroyed. The soil must only be slightly permeable, the ground must not be on a slope, and it must be near a source of water capable of furnishing 6000–30,000 cubic metres per hectare ($2\frac{1}{2}$ acres), and to maintain it at that for a certain time. Submersion is not efficient unless it be complete, so that it may soak deeply into the inundated ground and be executed under certain conditions. The submersion of fields and vineyards is in use in different countries of the globe, and everywhere gives encouraging results. The costs of submersion are not great when near a river from which the water can be led; the expense in that case only amounts to 41 francs per hectare, say 13*s*. per acre. But when the water has to be brought by pumping machines then it may amount to 200 francs per hectare. To this amount must be added the cost of manuring, which must be abundant as the immersion exhausts the soil. Submersion was recommended for the first time in France in 1864 for the destruction of insects in meadows and fields. In 1870 the same treatment was applied to vineyards attacked by the phylloxera, and lately it has been used to render forests wholesome.

**Submersion of Fields and Meadows.**—The inundation of meadows and fields destroys the larvæ of Coleoptera (beetles, weevils, etc.) and the grubs of the Lepidoptera, of which the following are the most important: (1) *Melolontha vulgaris*[1] (white worm), larvæ of the may-bug (cockchafer).—Artificial inundations have been in general use in Hungary since 1888 to destroy this larva. The meadows are submersed for eight days, and after that time all the white worms have disappeared. De la Blanchere has, however, seen water remain more than a month on ground infested with white worms without these being destroyed. That is explained by the fact that the larva of the cockchafer, very sensitive to moisture, to avoid contact therewith buries itself at such a depth as protects it from inundations. But it is only in impermeable ground that the white worm has the time to withdraw itself from the action of water. In such ground recourse should not be made to artificial inundation but to carbon disulphide. During the two years of its evolution, the white worm descends into the soil in October, to a depth of about 2 feet, so as to pass the winter, beyond the reach of cold, and it is only in spring that it ascends to the level of the roots to gnaw at them. According to the habits of this insect it is, therefore, in spring and in summer that the ground should be flooded. (2) *Phytonomus punctatus*, Fb.—The larvæ of this weevil are destroyed by flooding almost at the very outset. In America the cotton plantations are flooded to destroy the numerous parasites in the soil. (3) *Agrotis segetum*,[2] W.V. (grey caterpillar of the dart moth).—Flooding to destroy this insect ought always to take place in summer. In many cases flooding of the fields by the excess of moisture exerts a vexing effect on plants by retarding the ripening of the crops, or by developing adventitious plants or parasitic fungi. It is not so, however, with all crops, and it has been observed that submerged beets have more vigour and resist the fungi which ravage them better during drought, such as the *Phoma tabifica*,[3] the disease of the petiole of the leaves, the *Pleospora putrefaciens*[4] or the heart rot, and the bacillus of the *bacillary gummosis*[5] of vine. These diseases being less intense after submersion the method is advantageous. In the asparagus fields of the Delta region of the Sacramento River, flooding has proved quite practical as a control against centipedes in several cases, the best results having been obtained where the fields were kept thoroughly and continuously covered to a depth of a foot or more for two or three weeks.

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[1] COCKCHAFERS (white-worms).—Lamellicorn coleoptera, the larvæ of which are polyphagous. The common cockchafer is MELOLONTHA VULGARIS. The female lays thirty to fifty eggs in the soil, at a depth of 3—7 centimetres. They cause great damage in vineyards, meadows, beet-fields, and gardens. The larvæ are polyphagous, that is, gnaw indiscriminately the roots of all cultivated plants.

[2] AGROTIS (NOCTUA) SEGETUM, the common dart moth.—The imagos appear in the middle of May. They lay in June, July, and August on all low plants, chiefly beets, at the level of the collar; two weeks after laying they are hatched. The grubs are typical: dark earthy green, two yellowish lines on each ring, four small black spots, length 5 centimetres (2 inches). They pass the winter in the ground where they bury themselves deeply; they awaken in the spring and recommence their attacks up to May.

[3] PHOMA TABIFICA (beet and mangel rot).—The disease of the heart of the beet is in certain cases the result of the invasion of a fungus.

[4] ROT OF THE HEART OF THE BEET. *Pleospora putrefaciens.*—The rot of the heart of the beet may be produced by several fungi. That which is the most ordinary cause is the *Peronospora Schachtii*, which directly attacks the small leaves of the heart and covers them with a lilac flocked surface.

[5] GUM. *Gummosis* (bacillary of the vine).—This disease is due to the para-

**Submersion of Forests.**—Anderlind has shown the great service which the submersion of forests can render in the destruction of the insect ravagers of woods, the larvæ of which find a shelter under the moss and humus surrounding the stocks. In the different countries where submersion is in use the most dangerous insects only occasion insignificant damage, it is therefore one of the most powerful preventive measures against great invasions of certain forest parasites. The following insects are destroyed by submersion: *Melolontha vulgaris*, L. (common cockchafer). Weevils injurious to conifers: *Hylobius abietis*,[1] L. (large spruce fir weevil). The Scolytides so injurious to deciduous trees: *Hylesinus*[2] *ater*, F.; *H. opacus*, Er.; *H. angustatus*, Hb.; *H. cunicularius*, Kn. The *sawflies*, very injurious to coniferæ, because their larvæ not only attack the adult needles but prefer to devour the young shoots: *Lyda campestris*,[3] L., and *L. pratensis*, L., the larvæ of which bury themselves in August in the moss at the foot of trees to pass the winter there. *L. erythrocephala*, L. (red-headed Lyda), the larvæ of which hide at the foot of trees in the month of June. *Lophyrus pini*,[4] the larvæ of the second generation metamorphose into grubs in the humus of the forest after passing the winter there. *Gryllotalpa vulgaris*,[5] Latr. (mole cricket). Winter submersion has little action on it, because like the white worm it descends deeply into the ground at the approach

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sitism of a bacteria. The damage of the tissues consists in a gummy degeneration of the wood. It is believed that the disease enters through the pruning wounds, for this disease gains ground more especially from top to bottom.

[1] HYLOBIUS ABIETIS (the spruce pine weevil).—Brown, red-haired insect, 1 centimetre long. It appears in pine and spruce forests in May. The females lay their eggs at the foot of old trunks.

[2] HYLESINES.—These are Scolytides, which are distinguished from the bostrichus by their elongated legs and their corselet narrow in front. The larvæ and the perfect insects dig burrows in the trunks of trees. HYLESINUS PINIPERDA (the pine-destroying beetle) is a black insect, 4 millimetres, which appears in July and pierces the bark at the base of plants of a few years' growth; it there penetrates as far as the medulla and ascends the young tree, emptying it as far as the terminal bud, through which it issues. The female lays its eggs in the spring in a single sinuous burrow made in the liber; the larvæ afterwards excavate lateral burrows there. It attacks the *Pinus sylvestris* (Scots pine), *Pinus maritimus* (maritime pine), and *Pinus laricio* (Aleppo pine).

[3] LYDA CAMPESTRIS (pine saw-fly).—Black and yellow fly, 2 centimetres long, yellow wings, appears in June, and does the same damage to pines as the *L. pratensis* does to meadow plants. The larva buries itself in the moss at the foot of the stem in the month of August, there to pass the winter. LYDA ERYTHROCEPHALA.—The larva attacks pine needles and hides itself at the foot of the tree in June. LYDA PRATENSIS (meadow saw-fly).—Yellow and black fly, 13 millimetres in length.

[4] LOPHYRUS PINI (pine saw-fly).—1 centimetre long; head black, corselet yellow with black spots, abdomen yellow. The females lay their eggs inside the pine needles; the green larvæ gnaw the needles and weave against the leaves small cocoons of brownish silk.

[5] GRYLLOTALPA VULGARIS (mole cricket).—The mole cricket lives almost entirely on insects and their larvæ. To search for this underground food it cuts all roots that hinder it.

of cold. The following Lepidoptera: *Lasiocampa pini*[1] (or bombyx of the pine), the grub of which hibernates as chrysalis in moss at foot of tree. *Trachea piniperda*[2] and *Fidonia pinaria*,[3] L., both hibernating in ground in the state of chrysalis. Submersion also frees the forest from the rodents which undermine it, and which in winter nibble the bark of young trees. But if on the plain the difficulties of submersion are not great, on the slopes where it is necessary to trace a series of parallel channels which flood the ground, by overflowing, this method becomes very costly, especially if it is necessary to raise the water by means of turbines or pumps.

**Antiphylloxeric Submersion.**—In the beginning of the phylloxeric invasion in 1868, the sands of the dunes (sandhills) were found to be unfavourable to the propagation of this dangerous homoptera. The fact was observed at Aigues-Mortes, where vines planted in the dunes remained flourishing, whilst those planted in the neighbourhood died without exception. According to Foëx the sands exhibited a certain immunity to the phylloxera when they contained at least 80 per cent. of silica, but a small amount of clay or limestone sufficed to deprive the soil of this precious property. It was this immunity of the sands which gave the idea of submersion for the destruction of the phylloxera. It had formerly been remarked that long-continued rain was unfavourable to it, and that it shunned moisture by burying itself in the soil at great depths, only dying when the soil was thoroughly soaked. Eminent vine-growers concluded that submersion might be efficient, and have submitted a part of their vines to this treatment. The results obtained were surprising. The following table prepared by Faucon gives an idea of the improvement in the crop by the submersion of the vine:—

TABLE I.—*Showing the Effect of the Systematic Immersion of Vineyards on the Volume of Wine Produced.*

| Year. | Remarks. | Wine in hectolitres. | Wine in gallons. |
|---|---|---|---|
| 1867 | Year before the phylloxera invasion . . . . | 925 | 20,350 |
| 1868 | First year of invasion vines fumigated, non-submerged . . . . . . . | 40 | 880 |
| 1869 | Second year of invasion vines fumigated, non-submerged . . . . . . . | 35 | 770 |
| 1870 | First year with submersion without manure . | 120 | 2,640 |
| 1871 | Second ,, ,, ,, ,, ,, . | 450 | 9,900 |
| 1872 | Third year with submersion and manure . . | 849 | 18,678 |
| 1873 | Fourth ,, ,, ,, ,, (frost) . | 736 | 16,192 |
| 1874 | Fifth ,, ,, ,, ,, . . | 1,135 | 24,970 |
| 1875 | Sixth ,, ,, ,, ,, . . | 2,680 | 58,960 |

[1] BOMBYX PINI, LASIOCAMPA PINI (pine-tree lappet moth).—The female lays on the trunks of the *Pinus sylvestris* (Scots fir) in masses of 50 eggs which hatch about the middle of August. In the spring, in March or April, they re-ascend and attack the young shoots, frequently causing the death of the trees.

[2] NOCTUA OF THE PINE. *Trachea piniperda.*—Imago 1½ centimetres long, head, thorax, and upper-wings, red, with yellowish-white spots and lines on the latter. The abdomen and the lower wings greyish-brown. The female lays in April on the needles of the *Pinus sylvestris* (Scots pine).

[3] FIDONIA PINARIA (phalena of the pine).—Dark brown moth; the upper wings

Henceforth submersion was not slow in finding numerous partisans. It has been practised a little all through France, and its use has extended to abroad. At the present time its efficacy is entirely accepted, and also the manner in which it is necessary to operate without injuring the submerged plants. In many districts the vines have been saved from complete destruction, and in other districts, formerly uncultivated, productive and flourishing vineyards have been created. Camargue is an example. In this district, where, however, the inundation water is charged with salt, submersion presents special difficulties, and good outfalls must be organized if it is wished to avoid seeing the salt appear at great distances.

**Submersion in Actual Practice.**—To submerge certain privileged vineyards the water of a neighbouring river may be deflected in part and brought on to the land by a natural slope. In countries where water is scarce it has to be propelled on to the land by powerful centrifugal pumps working day and night. In all cases of winter submersion the vineyard is divided into compartments of 4—6 hectares (10—15 acres), separated from each other by small dams and communicatory through small ditches. Before running on the water, care must be taken that the surface is well levelled so that the water spreads regularly. In very windy districts Barral advises the vineyard being divided into more numerous compartments, the divisions between which serve to break the waves raised by the wind before they attain too great an amplitude. Duponchel, an advocate of underground irrigation, advises, in executing the latter, to excavate around each stock so as to lay bare the roots of the tree, thus forming as many closed basins which communicate with each other by small channels. Water is made to flow therein and is imbibed to a great depth by the soil around the stocks. When the ground is sufficiently wet and all the water has been absorbed, all that has to be done is to fill in the excavation with the dry soil placed on one side, to spread it and rake it. Submersion is performed either in winter or during the active period of the vegetation of the vine.

**A. Winter Submersion.**—Winter submersion is a process which cannot evidently be applied everywhere, and which requires special conditions, of which the following are the principal: (1) The ground must be slightly permeable, or very permeable but with an impermeable subsoil, such as is met with in the low plains of the French coast, and in isolated spots in the river alluvial soils of some of the chief watercourses. It is evident that too great a permeability of soil would require too large a volume of water. The daily decrease in the level of the water should not exceed a maximum of 10 centimetres (4 inches), a centimetre in depth corresponding to 100 cubic metres of water per hectare, say 1404 cubic feet per acre. (2) The ground ought to be perceptibly flat or very slightly inclined, a slope of 3 centimetres per metre (3 in 100) rendering submersion impracticable. (3) The vineyard should be situated, if possible, near to a stream of water, to an abundant spring, or to an artesian well, for it requires at

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of the female are striped with yellow bands, 4 centimetres from tip to tip, the male 3 centimetres. The caterpillars gnaw pine needles which they generally cut through the middle, letting one-half fall to the ground. The ravages last from August to October.

least 6000 cubic metres of water per hectare, 84,780 cubic feet per acre. During the duration of the submersion, there is a daily loss of water, not only from absorption by the soil but also from evaporation into the atmosphere. The amount of water absorbed daily and the duration of the submersion have been studied by Chauzit and L. Tronchaud-Verdier, who have prepared the following table :—

TABLE II.—*Showing the Daily Loss of Water by Absorption by Various Soils during Submersion.*

| Soil. | Duration of submersion. | | Daily loss of water. |
|---|---|---|---|
| | Autumn. | Winter. | |
| Slightly permeable . . | 50—55 days | 55—60 days | 1 centimetre |
| Fairly ,, . . | 55—60 ,, | 60—65 ,, | 1 to 4 centimetres |
| Permeable . . . | 65—70 ,, | 70—75 ,, | 4 to 7 ,, |
| Very permeable . . | 90 ,, | 90 ,, | 8 to 9 ,, |

Evaporation into the atmosphere averages 6 millimetres in twenty-four hours in winter, though it reaches 10 millimetres in summer. (That is at the rate of an output of 1 litre per second per hectare, which is calculated in general as the general output of the channels serving to irrigate meadows.) (4) The duration and efficiency of the submersion, moreover, depends on the climate. It is known that in France it can only be practised in the centre and south. In the north the vines would have to pass the winter surrounded by ice, which would seriously injure them. The duration of the submersion should average sixty days in south and thirty days in central France.

**B. Submersion During the Active Period of the Vine.**—Where large quantities of water are deficient, summer irrigations may be adopted. Debray has, in fact, remarked that the phylloxera is killed more easily during the active period of the vine, and that the duration of the submersion can be reduced to eight days in September, while fifteen to twenty days are required in October, and forty to sixty days in winter. In this connexion the underground irrigation described by Duponchel produces the best effect. So that submersion may be complete and efficacious, *i.e.* so that the water can penetrate 2 feet into the soil, it requires 1000—1200 cubic metres of water per hectare, say 250—300 litres (55—66 gallons) of water per stock. It is executed during dry periods, when vegetation is not very active. It has been found, on the other hand, that short, repeated irrigations lasting forty-eight hours in summer, especially if underground, are as injurious to the phylloxera as long winter irrigations. Whilst even three days' immersion in cold districts are injurious, underground irrigations of forty-eight hours in the dry regions of the South have a favourable action on the development of this plant. The causes, which in the exceptional conditions of the French climate insure the prosperity of the vine and the quality of French wines, are none other than the climate itself and the method of culture applied, the hoeing of the soil. It creates on the surface of the soil a shallow layer of friable earth, which by breaking the continuity of the capillaries arrests all evaporation from below. The rain-water thus imprisoned in the soil without communication with the exterior air constitutes that lasting store of underground moisture, which can only be evaporated by the plant which aspirates it by the roots and which loses it by the leaves. The sap thus elaborated acquires that peculiar property of being specially apt to develop fruits, whilst in moist districts submerged too often the more aqueous sap perfectly produces herbaceous vegetation and yields few grapes. To produce grapes of superior quality the fruits must be developed in a warm medium, and the roots be in a moist and warm medium. These essential conditions are wanting when prolonged superficial submersion is practised, but are not greatly affected by the underground irrigations recommended by Duponchel. Superficial sprinkling of the soil never gives useful results as regards grapes, but develops branches full of leaves (*pampres*). The superficial evaporation of the water so sprinkled by cooling the soil must retard the ripening of the crop. Submersions would therefore in general be rather prejudicial to the quality of the crop of a healthy vine. As a curative agent, they produce, on the other hand, two effects equally advantageous, they enable the vine to reconstitute its radicular apparatus (root hairs) more or less atrophied by the gnawing of this pest. From this point of view, the irrigation of the vines may be regarded as of practical utility, but it should be executed with the greatest of precaution so as to modify as little as possible the special conditions which insure the quality of the grape. A sufficient imbibition must be created to be injurious to the phylloxera, and favourable to the development of root filaments, avoiding all loss of heat by superficial evaporation. These conditions are realized by underground irrigation, especially if it be accompanied by the addition of nitrogenous manures. In spite of the good results obtained by submersion and underground irrigation, these can only be regarded as a palliative and not as a curative method. Long winter submersions, short summer irrigations, do not kill all the phylloxeras which ravage the roots, and a new invasion always occurs: thus the treatment should be annual. To diminish the number of the insects and stimulate the vegetative energy of the plant is not a sufficient remedy, and to re-establish the health of the plant it is well to destroy the parasites by powerful insecticides, such as carbon disulphide and sulphocarbonates, at the same time as the radicular system of the vine is strengthened by subterranean irrigations. Simple submersion along with strong manuring, by stimulating growth by moisture and fertilizers perceptibly diminishes the action of the phylloxera; but it only creates, in reality, a *modus vivendi* between the parasite and the plant. In these conditions the latter may produce abundant growth of leaf, but it will only give in the majority of cases a mediocre grape. It follows from the interesting researches of Maquenne and Dehérain, that when a soil is withdrawn from the action of oxygen, as happens when it is covered by a sheet of water, the nitrates which it contains disappear rapidly, owing to the action of certain reducing ferments. On the other hand, Muntz has tried to find out how the roots of vines immersed for two months can respire. This long privation of air ought to be injurious. To prove it, Dehérain and Vesque submitted vines for fifteen days to immersion in distilled water, and found that they rapidly died, whilst others placed in aerated water were in perfect health. It is, therefore, the want of oxygen which in submersion may well prove fatal to vines, and that more readily when it is practised during the period of activity of the sap. River water used for submersion is the best, because it always contains air and nitrates, and vines submerged in these conditions resist for two months at least. That is an established fact which it is interesting to explain. The above-named scientific observers believe that the nitrates reduced by the ferments are converted into laughing gas, which contains oxygen, and may support the respiration of the roots. This reduction observed in submerged land may become useful to vegetation, as it prevents the asphyxia of the vine. It is thus necessary to spread on the land an appreciable amount of nitrate if it be desired that the submersion should not injure the vine. French vine growers use in fact 600 kilogrammes of nitrate per hectare (528 lb. per acre), which is in no way exaggerated, but appreciably increases the cost of immersion. Certain muddy waters, such as those of the Dordogne and Garonne, for example, enable the amount of the manure to be reduced a little. However, in spite of all the care brought to bear on immersion, there are vines which do not support the treatment. Espitalier cites the following species which die very rapidly: La Carignac, le Grenache, le Mourvedre, la Clairette, le Malbec, le Merlot, and in general all the valuable species, whilst the Cabernet, the Petit Bouschet, and l'Aramon accommodate themselves well to it. This explains why simple immersion has been replaced in large vine-growing countries like the Gironde by irrigations with sulphocarbonate. Another drawback of submersion is that the vines planted in low grounds are attacked by all the cyptogamic parasites which multiply in moist districts and suffer more therefrom than anywhere else.

Moreover, the following, according to Tisserand, is the increase in the use of immersion and of insecticides in the treatment of the vine:—

TABLE III.—*Showing the Increase in Area of the Submersion and Insecticidal Treatment of Vines in France.*

| Year. | Submersion. | Carbon disulphide. | Potassium sulphocarbonate. |
|---|---|---|---|
| | Hectares. | Hectares. | Hectares.[1] |
| 1880 | 8,093 | 5,547 | 1472 |
| 1881 | 8,195 | 15,933 | 2809 |
| 1882 | 12,543 | 17,121 | 3033 |
| 1883 | 17,792 | 23,926 | 3097 |
| 1884 | 23,303 | 33,446 | 6286 |
| 1885 | 24,339 | 40,585 | 5227 |
| 1886 | 24,500 | 47,215 | 4459 |
| 1887 | | | |
| 1888 | 33,455 | 66,705 | 8089 |
| 1889 | 30,336 | 57,887 | 8841 |
| 1890 | 32,738 | 62,208 | 9377 |

[1] A hectare is 2½ acres approximately.—TRANS.

To sum up, submersion, if of undeniable efficacy, is a primitive process, with many drawbacks, which should be advantageously replaced by irrigations with sulphocarbonate or with carbon disulphide. Amongst the antiphylloxeric treatments we should advise, according to circumstances, the following choice: Annual submersion may be applied where exceptional conditions combine, accompanying it, however, by very abundant manuring. Irrigations with sulphocarbonate and carbon disulphide are reserved for *de luxe* vineyards, such as those of Bordelais, Burgundy, and Champagne. Carbon disulphide, applied by means of the soil *injector*, is to be adopted preferably in small and medium cultures, and especially where the want of water renders submersion too costly.

**Spraying.**—Spraying with cold water destroys the following parasites: *Capnodium* (*Fumagine*[1] or smut of fruit trees).—Sorauer recommends playing a jet of cold water on the crown of the trees after pruning that part. However, this operation must be repeated every evening in summer. *Capnodium salicinum*, Mntgn. (hop black), may be prevented by spraying the leaves with cold water and repeating the process several days (Niajels). *Tingis pyri*,[2] Fb.—The pear tiger-beetle is fought against in the same way by spraying night and morning under the attacked leaves with cold water, or with a little soap added (Montillot). *Tetranychus telarius*,[3] L. ("red spider"), which forms on different plants a disease called "la Grise," is very sensitive to moisture and does not stand repeated cold-water spraying long (Thomas). *Bryobia ribis*[4] (gooseberry acarus) may be fought against by frequent sprinkling of the leaves. Spraying with water can thus be used as a preventive against different species of Fumagine or smut (*Capnodium*), as a means of killing acari, of which the Tetranychus (red spider) is the most widespread and injurious.

(b) **Hot Water** acts very energetically on insects and fungi, which die in contact with boiling water. Plants and their seeds generally stand heat better. That enables their parasites to be destroyed without injuring themselves.

**Resistance of Insects to Heat.**—All insects in seed are destroyed below 100° C. (212° F.). Bruchideæ (small weevils, pea-weevils) die in five minutes at 60° C. (140° F.). Ordinary weevils do not stand 50° C. (122° F.). Grubs touched by water of 50—80° C. (122—176° F.) die without exception. Coleoptera (beetles) which sometimes stand great heat never bear 100° C. (212° F.) (Schribaux, Bussard, and Etienne).

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[1] Fumagine. *Capnodium* (smut of fruit trees).—Fumagine is the term applied to the black coating which appears on certain plants infested by plant lice or coccides (scale insects). The damages caused by this fungus are serious because they injure the regular functions of the leaf, and they, moreover, soil the fruit which they render unfit for food. The coccis and consequently the fumagine are very injurious to trees, especially in orchards.

[2] Tingis pyri. *Tiger of the Pear-tree.*—This brown flat hemiptera, 3 millimetres in length, appears in June. Larvæ, grubs, and adults live as one family on the lower surface of the leaf or the young shoots, and riddle them with their pricks. The young shoots wither and the leaves brown.

[3] Tetranychus telarius (red spider so-called).—A red, polyphagous acarus, it attacks the most diverse plants, chiefly trees, haricots, peas, clover, pumpkins, beets, hemp, hops, roses, limes, chestnuts, willows, and fruit trees. It produces the same symptoms on all these plants. The leaves, prematurely discoloured, become copper yellow or red, and eventually wither, to fall before the end of summer. The under surfaces of these leaves are covered with a very fine light tissue and white pellicles, in the midst of which the red acarus moves.

[4] Acarus of the Gooseberry. *Briobia ribis.*—Causes degeneration of the buds, leaves, and shoots, making them stunted and clustered.

**Resistance of Seed to Heat.**—Seeds can undergo a dry heat without injury, whilst the action of moist heat, and of water above 60° C. (140° F.) is often injurious. Seed-corn, with the exception of maize, can support a heat of 100° C. for an hour without its germination being affected. In spite of the considerable loss in water which the grain undergoes in such conditions, seed-wheat, for example, which contained 13 per cent. of water before being heated lost 9·4 of water during the operation. Their vitality is not diminished. Of Japhet seed-wheat heated for an hour in a stove at 105° C. (221° F.) 97 per cent. still germinated; at 115° C. (239° F.) 95 per cent.; at 116° C. (240·8° F.) 93 per cent.; at 120° C. (248° F.) 56 per cent.; at 125° C. (257° F.) 4 per cent. [Potatoes dipped in boiling water do not germinate.]

During researches on the *Alucite*[1] Doyere likewise succeeded in heating seed-wheat dried *in vacuo* to 100° C. (212° F.) without it losing its faculty of germinating. By previously drying seeds at a low temperature Jodin heated grains of seed-wheat to high temperatures without alteration. Peas and garden-cress seed heated directly to 98° C. (207° F.) for ten hours were no longer capable of germination, whilst others submitted to the same heat for the same time stood the heat perfectly, after being heated for twenty-four hours to 60° C. (140° F.). The peas retained a germinating capacity of 60 per cent. Therefore, if seed be heated in such a way as to allow the water to evaporate previously, by heating in an open vessel or in presence of such substances as sulphuric acid, calcium chloride, and quicklime, they undergo no alteration. Seed-peas under such conditions stood heating for 206 days at 40° C. (104° F.).

**Resistance of Fungi to Heat.**—Fungi spores are generally remarkably sensitive to moist heat, but *per contra* they stand dry heat well. Schindler found that the spores of the *Ustilagineæ*[2] which resist very great dry heats, are rapidly injured if the hot medium is saturated with water vapour. In these conditions the spores of black rust perish at 60° C. (140° F.), those of brown rust at 45—50° C. (113—122° F.). Herzberg has compared the resistance of spores of different ages to the action of heat, and found the following temperatures as those at which they succumbed :—

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[1] Alucite. *Sitotraga cerealella.*—Moth (tinea) of 6 millimetres in length, greyish-yellow, with long filiform antennæ. The female lays red eggs in the depression of the grain of wheat; before harvest the caterpillars penetrate into the interior of the grain stored in the granary where they finish their development; they gnaw the whole interior and only respect the epidermis. After having emptied the inside of the grain they there weave a cocoon and are converted into chrysalides. The temperature of the heap of wheat attacked increases 10° C. (50° F.).

[2] Ustilago.—The mycelium of the *Ustilagineæ* lives in the interior of the plant; it gives rise to numerous fertile branches, inside which the spores are formed, which detached form a black powder. These are the dormant spores. *Ustilago Maydis* (maize smut) may directly invade the young tissues of the adult plant. None of the other *Ustilagineæ* can enter the nurse plant except at the birth of the latter. The mycelium which develops forthwith in the tissues of the seedling on the level of the ground, extends gradually into the whole plant without perceptibly affecting the growth of the latter. It afterwards traverses the whole nurse plant, and whilst life is gradually extinguished in the lower parts of the plant it concentrates itself towards the top and arrives at maturity in the ears at the end of the period of growth of the plant. The spores of *Tilletia* are enclosed at harvest time in the interior of the rusted grain and are almost all carried to the granary where they are spread over the corn during threshing.

Table IV.—*Showing the Temperatures at which the Spores of different Species of Ustilago are Killed.*

| | U. Jensenii. | U. Avenæ. | U. Perennans. | U. Hordei. | U. Tritici. |
|---|---|---|---|---|---|
| | °C. | °C. | °C. | °C. | °C.[1] |
| Old spores . | 47—50½ | 45½—47½ | 40½—42 | 43½—45 | 46 —47½ |
| Young spores | 50—53 | 50½—53½ | 47½—50½ | 45½—47¾ | 45¼—47¾ |

It follows that the young spores are more resistant than the old ones, and that the temperature required to destroy the vitality of a spore is not the same for spores of different species.

**Use.**—The sensitiveness of parasites to hot water and the comparative resistance of plants have permitted the use of different treatments, especially preventive, to free plants from certain diseases.

**Immersion or Steeping.**—This consists in dipping seeds or plants in hot water to free them from disease germs adhering to their surface.

*Hot Water Steeping of Seed-corn to Kill Disease Spores.*—Steeping seed-corn in hot water is practised before sowing to destroy the dormant spores of smut and bunt, which adhere to their surface and help to propagate these diseases. Brefeld, observing that cold water was injurious to the development of the spores of bunt, tried washing seed with cold water, and so obtained an appreciable but incomplete result. On the other hand, hot water has been recognized as deadly to the spores of these fungi, and treating the seed by hot water would wholly suppress cryptogamic diseases if the seed formed the sole factor of their propagation. To get satisfactory results steeping the seeds in hot water should be done in a strictly scientific manner. It is only efficacious if the temperature of the bath has been rigorously maintained at a certain degree. A greater heat than that required to kill the spores should be avoided, for it will appreciably diminish the germinative capacity of the seed, and may even destroy it. If there be a difference of sensitiveness between the seeds and the spores as regards heat, it is so small that a difference of a few degrees may be fatal. A low temperature should also be avoided, as it favours the disease instead of preventing it. Warm moisture helps, in fact, a premature development of the spores. The promycelium and the sporidia formed then attack the young plant as soon as hatched. It is a known fact that bunt as well as smut are more injurious to the plant the younger they attack it. When well done, steeping in hot water imparts to the seed in many cases a greater germinative capacity, so that the plant has acquired a certain development when the spores which have escaped the treatment germinate. That is one reason in favour of steeping; the other methods of treating seed generally retard their germination. Steeping gave in certain cases results which it had been impossible to obtain by sulphating (Kuhn's), and it is in such particular cases that its use is prescribed, in spite of the difficulties of carrying it out which the farmer has to face in a peculiarly complicated plant, and the minute practical care required to secure a good result. B. Prevost was the first to observe that steeping seed-corn in hot water diminished the power of contagion of smut. Jensen studied this treatment with great care and perseverance, and other investigators confirmed Jensen's very precise observations and conclusions. The following, according to Eriksson, is the manner in which Jensen's method should be applied on the large scale. The operation requires (1) A boiler or large pot in which to boil water. (2) Three tubs: No. 1 for hot water, No. 2 for tepid water, No. 3 for cold water. (3) Two willow baskets, completely lined inside, including the lid, with bolting cloth. (4) A thermometer. After having prepared a certain amount of boiling water, 50 litres (11 gallons) are withdrawn and run into the first tub, which is cooled to the desired temperature with 40—50 litres (9—11 gallons) of cold water. In the second tub about 20 litres (4·4 gallons) of boiling water are mixed with 80 litres (17·6 gallons) of cold water so as to get a temperature between 25° and 30° C. (57—86° F.). Cold water is run into the third tub. The seed to be treated is placed in baskets, the lids of which are carefully closed so as to enable them to be completely immersed. Each basket contains about half a bushel of seed. After firmly attaching the basket to a stick it is plunged, first in the cold water to moisten the grain completely, then the same operation is repeated in the tepid water, taking care to raise up the basket and re-dip it several times. Finally it is dipped for five minutes in the hot water, raising and lowering the basket. The operation is finished, and the grains so treated can be immediately sown by hand, or they may well be spread out to dry. It goes without saying that it is necessary to disinfect the boards on which the grain is spread perfectly, as well as the bags to contain it, by hot water, Bordeaux bouillie, or simply a solution of sulphate of iron. With three men and two baskets 400—500 litres (11—13¾ bushels) of grain may be disinfected in an hour. Kellermann and Swingle have simplified this process by dispensing with one of the three tubs, the cold water one. They only use a tub of water at 43—54° C. (109·4—129·2° F.) and a tub of water at 56° C. (132·8° F.). They use a basket of wire gauze of a capacity of 36 litres, say 8 gallons, which they only half fill with grain, or simply a canvas bag. They first dip the basket for a minute in tepid water to warm the grain, then fifteen minutes in hot water at 56° C. They consider it useless alternately to raise and lower the basket into hot water. Each cereal is attacked by one or several species of rust, and it is necessary to examine the action of Jensen's treatment on each of its parasities, *Ustilago Hordei*, Bref., on barley (*Hordeum vulgare*) and *Ustilago Jensenii*, Rost., on barley (*Hordeum distichum*). The steeping of grains of barley exhibits certain difficulties when these are still surrounded with glumes. By ordinary steeping, the spores between the grains and the glumes are not killed even if the water is raised to 60° C. (140° F.), whilst in an atmosphere containing the vapour of water, Jensen has observed destruction to be complete at 52½° C. (126½° F.). Eriksson got excellent results by softening them for hours in cold water before steeping, and allowing them to swell for four hours in an aerated place, afterwards bagging them up. It suffices, therefore, to immerse the grain for five minutes at 52·5° C. (126½° F., Jensen), at which heat all the spores perish. The water can, without fear of diminishing the germinative capacity of the seed, be heated up to 60° C. (140° F.), barley standing that heat without injury. According to Kuhn, it is injurious to leave the grain for twelve hours in cold water before proceeding to the (hot) steep, but by not exceeding four hours Sorauer found that such was in no way injurious to the development of the seeds. Kellermann, Swingle, and Kirchner dispense entirely with the first immersion in cold water, and claim to have obtained satisfactory results by one dip in hot water at 52·5° C. (126½° F.), even if the grains be glumed. Kirchner found that after a dip of five minutes in water of 56° C. (132·8° F.) grains of seed-barley germinated thus :—

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[1] To bring to Fahrenheit, multiply by 9, divide by 5, and add 32.

Table V.—*Showing Effect of Steeping Seed-barley in Hot Water on Germinative Capacity.*

| | Germinated after two days. Per cent. | Germinated after ten days. Per cent. |
|---|---|---|
| Treated . . . . | 74·5 | 98·0 |
| Untreated . . . . | 69·75 | 97·0 |

Besides the disinfectant action there is thus an evident increase in the germinative capacity of the seeds.

*Ustilago Tritici*, Jensen (smut of wheat, *Triticum sativum*); *Tilletia caries*, Tul., “ stinking smut ” or “ bunt ” of wheat; *Tilletia levis*, Kuhn (loose or flying smut of wheat).—According to Herzberg, the spores of *Ustilago Tritici* are destroyed at a temperature of 48° C. (118·4° F.), and those of *Tilletia* do not germinate after immersion in water of 55—56° C. (131—132·8° F.). By treating wheat grain by one immersion of five to fifteen minutes in water of 56° C. (132·8° F.), Sorauer obtained the following results :—

Table VI.—*Result of Steeping Seed-wheat in Hot Water during different Periods of Time.*

| | |
|---|---|
| Untreated grain . . . . | 87 per cent. of plants which gave 5·17 per cent. of “ bunted ” ears. |
| Grain treated five minutes . . | 91 per cent. of plants which gave 0·225 per cent. of “ bunted ” ears. |
| ,, ten minutes . . | 87⅔ per cent. of plants which gave 0·157 per cent. of “ bunted ” ears. |
| ,, fifteen minutes . | 87⅔ per cent. of plants which gave 0·071 per cent. of “ bunted ” ears. |

By treating the grain with 0·5 per cent. of blue vitriol he obtained 86⅓ per cent. of plants. It may therefore be inferred that an immersion of five minutes suffices, and that it has an advantage over blue vitriol because it stimulates germination instead of retarding it like the latter. Klebahn, however, is of opinion that immersion has no advantage over vitriol steeping, and Kirchner asserts that it diminishes the germinative power. Selby found that the same result was got by immersion as by treatment for twenty-four hours with a solution of 0·5 per cent. of blue vitriol, 0·2 per cent. of formalin, and 0·75 per cent. of potassium sulphide. When wheat is immersed on the large scale against bunt it is well to dip the grain first in water, skim it, and cast aside all those grains which float. These are precisely the bunt-infested ones. Those which lie on the bottom of the water are alone dipped in the hot water. *Ustilago Avenæ*, Rost. (loose smuts of oats, *Avena sativa*); *Ustilago perennans*, Rost. (smuts of oats, *Avena elatior*).—The spores of *Ustilago Avenæ* stand air heated to 52° C. (125·6° F.), but they do not stand dipping in hot water at 54—56° C. (129·2—132·8° F.) (Sorauer). Kirchner found that seed-oats treated in that way gave the following results against untreated :—

TABLE VII.—*Showing Effect of Steeping Seed-oats in Hot Water on Germinative Capacity.*

| | Germinated in two days. Per cent. | Germinated in ten days. Per cent. |
|---|---|---|
| Treated . . . . | 24·75 | 84·5 |
| Untreated . . . . | 6·75 | 81·75 |

Treatment on the large scale lowers the percentage of diseased plants to about 0·2—0·7 per cent. (Eriksson). According to Kellermann and Swingle, a fifteen minutes' dip in water at 55·6° C. does not alter the germinative power of oats, and all authors agree in saying that the immersion of seed-oats is better than treatment with blue vitriol, because it stimulates instead of retards the germination. It is therefore from this point of view a useful discovery, and Klebahn is of opinion that this treatment, general for all other cereals, is prescribed for oats.

*Urocystes occulta*, Rabenh. (smut of the stems of rye).—By immersing seed-rye for five minutes in hot water Kirchner obtained against untreated grain the following results :—

TABLE VIII.—*Showing Effect of Steeping Seed-rye in Hot Water on Germinative Capacity.*

| | Germinated in two days. Per cent. | Germinated in ten days. Per cent. |
|---|---|---|
| Treated . . . . | 91 | 95·5 |
| Untreated . . . . | 95·25 | 98·0 |

Trials on a large scale by Klebahn did not give better results. The immersion of seed-rye presents no advantage in this case over treatment with blue vitriol, because it retards germination like the latter.

*Ustilago Panici-Miliacei*,[1] Wint. (smut of millet).—Treatment with blue vitriol or immersion may be employed indifferently, as they both give the same results. The millet seeds must be left seven and a half to twelve minutes in water at 55° C. (131° F.).

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[1] USTILAGO PANICI-MILIACEI (smut of millet).—This invades all the parts of the flower of millet and damages them. The spores are formed in the inflorescences when they are yet enveloped in the sheath of the top leaf.

*Ustilago Maydis,*[1] Corda (smut of maize).—Nijpels prescribes the immersion of maize by Jensen's method; it gives good results.

*Ustilago bromivora,* Fisch. (smut of brome grass, *Bromus arvensis*).—According to Rostrup immersion has also been tried with success against this disease.

*Sphærella Tulasnei,* Junez (black of cereals, *Cladosporium herbarium*).—Giltay prevented the development of this disease by immersion in hot water. Kolpin Kavn prevented it entirely on barley and oats by Jensen's immersion at 52—53° C. (125·6—127·4° F.) for five minutes, after previously softening the grain for fifteen minutes in cold water.

*Puccinia* [2] (rust of cereals).—The numerous experiments of Galloway in America to diminish the rust of cereals by dipping the seed for fifteen minutes into water heated to 56° C. (132·8° F.) have not given the result anticipated. The treated seed gave as many diseased plants as the untreated. That is due to the method of development of the fungus, which does not appear, in fact, to propagate itself through the seed. Immersion has also been used to prevent beet diseases, due to fungi propagated through the seed. These diseases are *Pythium de Baryanum,* Hesse; *Rhizoctinia violacea* [3] Tul. (beet Rhizoctone); *Phoma tabifica,* Pril. et Del. (disease of the petioles of the leaves); *Pleospora putrefaciens,* Frank. (rottenness of the heart). Jensen's method has given excellent results, and it follows from the trials made by Hollrung that immersion, instead of injuring the seed, on the contrary stimulates their germination. Treatment with cold water greatly increases the germinative capacity of beet seed; but it must not be kept ninety days after immersion before sowing, because the effect gradually disappears. If the seed be sown soon after immersion an excellent result is obtained with very few diseased plants. The procedure is as follows: The seed, in a wire-gauze basket, is immersed for six hours in cold water, left to drain ten to twelve hours in an airy place, then dipped for five minutes into water heated to 53·5° C. (128·3° F.), taking care to dip and raise the basket at regular intervals. Nothing further is required but to pass the seed into a bath of cold water, and it may be sown at once, or after standing for not more than ninety days. Summing up, Jensen's method sometimes gives results inferior to treatment by blue vitriol, because it scarcely ever diminishes the germinative capacity of the seed treated; it is only really prescribed for the disinfection of seed-oats, for the results are undoubtedly superior. For all other cereals blue vitriol, Bordeaux bouillie, or potassium sulphide may be prescribed. The latter process was recommended by Jensen himself in 1895 ("Ceres" powder) as capable of replacing immersion.

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[1] USTILAGO MAYDIS (smut of maize).—This smut attacks the fructified maize, not only in the floral bracts where it forms large, unshapely smutty tumours on the panicles of the male flowers, but also on the stems themselves where the amassed spores form bulky excrescences.

[2] *Puccinia.* RUST OF CEREALS.—At least three different species of rust are to be seen on grain crops. They are uredinæ which are termed heteroic because during their cycle of evolution they must live on nurse plants of different orders. The uredinæ are parasitic fungi the mycelium of which grows exclusively in the interior of the body of green plants. Their spores are generally formed under the epidermis of the nurse plant, whence it spreads outwards through the tearing of the epidermis which occurs. It is from the orange-brown colour of their spores that the uredinæ are termed *rusts.* The leaves charged with rust spots are soon exhausted, they turn yellow and die prematurely.

*Puccinia graminis.*—This rust attacks wheat, barley, oats, a host of common grasses, such as meadow grass, couch grass, dactyla, agrostis, foxtails, festuca, etc. It is the most dangerous rust of cereals. It particularly attacks the leaves, their sheaths, and the stalks (straw).

*Puccinia coronata.*—This rust is peculiar to oats. It has the uredo and puccinia forms on oats, but the æcidium form on different plants of the *Rhamnaceæ,* particularly buck-thorn and black alder.

[3] *Rhizoctinia.*—Parasitic fungi which develop on plant roots, penetrate into their interior, and kill them. Their vegetative system is highly developed and enables them to pass in the soil from one root to another. Sclerotes, sorts of tubers, enable them to live a latent life when outside conditions are unfavourable to their development.

**Immersion of Seed against Insects.**—*Phylloxera.*—Balbiani's researches on resistance of phylloxera eggs show that non-rooted buds can be treated preventively by one dip of five to ten minutes in water heated to 45—50° C. Experiments renewed in 1887 by G. Couanon, G. Henneguy, and E. Salomon confirm the results obtained. This method is currently used to-day. Not only does it cause no prejudice to slips catching root, but it seems, on the contrary, to facilitate it. And the importance of this treatment is so much the greater as it follows from determinations made in Algeria (1885), in Champagne (1890) and in Lorraine (1894), that new phylloxera hot-beds have no other origin than plants coming from countries infested with this formidable insect. G. Couanon and J. Michon resumed the same experiments and extended them to rooted plants which are most frequently used in the reconstitution of vineyards. Rooted Noah plants, dipped for three, four, and five minutes in water at 53° C. (127·4° F.) (51° C. at the exit, 123·8° F.), were planted at the same time as test samples. They took root completely, as well in the greenhouse as in the open air, and the vines grew very finely. Dipping in water at 53° C. (127·4° F.) is thus a practical and economic method for disinfecting vines, rooted or not, for it kills at the same time both the insects and their eggs. It has also the advantage over the sulphocarbonate treatment recommended by Mouillefert, that it does not require, like this latter, two to three hours, and has no injurious action on the plants (Balbiani). Disinfection by hot water gives very satisfactory results; the same process has been used for other fruit trees intended for sale, and coccides, the woolly aphis,[1] and other injurious insects, have been simultaneously destroyed. According to Danesi, all fruit trees, the peach excepted, stand very well being dipped for five to ten minutes into water at 53° C. (127·4° F.). To ensure complete disinfection the whole plants must be entirely dipped into the water at 53° C. (127·4° F.), and dried in the air on a copper grating. They can then be packed in disinfected moss and despatched.

*Bruchus Pisi*, L. (pea-weevil).—To kill this insect Fletcher recommends the following method: A vessel is taken which is half-filled with the infested peas, and boiling water poured on until they are entirely submerged. The vesssel is then filled with cold water and left to stand for twenty-four hours. The peas which do not suffer from the treatment and which are entirely freed from the insects they sheltered can then be sown. De la Bonnefon advises dropping the peas into water and leaving them there for some hours. The peas which remain at the bottom are put into an oven the temperature of which is 60° C. (140° F.). After some time they are taken out and then sown.

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[1] Woolly Aphis. *Schizoneura lanigera* (also known as *Eriosoma lanigerum*).—This aphis, like the phylloxera, lives as well on the roots as on the aerial part of the plant, but it prefers the branches to the roots. It especially attacks the apple-tree. The diseased condition of the trees is known by their perishing, and their leaves which rapidly turn yellow and fall during summer.

**Hot Water Spraying.**—Spraying plants with hot water has not only been used to destroy injurious insects, but also to cause certain fungi to disappear, such as the *Erysipheæ* [1] or mildews, which crawl on the surface of the epidermis without ever penetrating into the interior of the tissues. It is owing to this peculiarity that they can be destroyed by hot water. The leaves of plants stand without injury sprayings of 77—85° C. (170·6—185° F.), whilst at that temperature the mildews disappear entirely. The roots alone of the plant must be protected, because they suffer from contact with water at that temperature. Hot spraying has been used against the following mildews: *Uncinula americana* [2] How. (oidium of the vine); *Sphærotheca pannosa*, Lev. (mildew of the rose bush); *Sphærotheca Castagnei*, Lev. (mildew of the hop).

*Hot Water Treatment of Soil against Woodlice.*—Where apparatus is available for the distribution of water at a high temperature in glass-houses, the treatment is undoubtedly the most radical in the control of woodlice. To determine the effect of temperature on these woodlice, a thermostatic bath was employed. In this was placed a vessel containing soil into which the woodlice could be introduced. With the water in the thermostat at 147° F., the soil at an internal temperature of 146° F., and with a surface temperature of 124° F., all woodlice introduced on the soil surface were killed in 30 seconds. With the thermostat temperature at 140° F., the soil internally at 136° F., and the soil surface at 108° F., woodlice similarly introduced were killed within two minutes. Woodlice dipped for half a second in water at 149° F., died within a few minutes after immersion. These experiments show that the *Armadillidium vulgare* is easily killed by water at comparatively low temperatures and accounts for the efficiency of the hot-water treatment.

Hot water has found numerous applications against insects very sensitive to heat. *Galeruca* [3] of the elm; *Formica*, ants; *Pierides* [4] of the cabbage; *Cochylis pyralis* of the vine; Cabbage lice; *Diaspines*, coccides, red spider.

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[1] Erysipheæ. *Mildews.*—Mildews form on the leaves and on the young parts of the plants powderish, whitish spots. The mycelium of the mildew is always superficial, it crawls on the surface of the epidermis without penetrating into the interior of the organs. It sinks its suckers in the epidermis.

[2] Oidium of the Vine. *Uncinula americana, Oidium Tuckeri.*—The mycelium of this fungus lives on the surface of the plant and draws its nourishment from the cells of the epidermis by numerous suckers. The organs attacked are rapidly altered, the extremities of the young shoots wither, the leaves shrivel up and die, but the effect is still more deadly on the grapes, which crack and rot.

[3] Galeruca of the Elm. *Galeruca clamariensis.*—The larva of this insect is as injurious as the perfect insect. The eggs laid on the leaves hatch in May; the larvæ, very voracious, reduce the leaves to skeletons up to the time they nymphose. The parenchyma of the leaves being gnawed the veins alone persist, and the leaves, reduced to a skeleton, soon fall.

[4] Pieris brassicæ. *Pieris rapæ* (large white cabbage butterfly, small white cabbage butterfly).—They are white, diurnal, well-known butterflies. The former

*Galeruca calmariensis* (*Galeruca* of the elm).—To destroy this insect, Robert sprays the stock and the lower part of the trees with boiling water. The time selected for doing so is when the larvæ are being transformed into grubs around the stock, *i.e.* about the end of July or beginning of August.

*Formica* (ants).—Boiling water destroys ants. It may be used whenever there is no risk of touching the roots, which do not stand hot water at that temperature.

*Pieris* (*Pierides* of the cabbage).—When they are not destroyed when they are small, the grubs of *Pierides* (white butterflies) so ravage cabbage as to render them unsaleable. Riley has observed that the grubs die when they are sprayed with water at 55° C. (131° F.), whilst cabbage leaves do not suffer at that temperature.

*Cochylis ambignella*, Hubn. (*Cochylis* of vine); *Tortryx vitana* (*Pyralis* of vine).—Scalding is the best method of destroying these insects. It consists in spraying the stocks with boiling water when vegetation is arrested, and when the insects have chosen the fissures in the bark as a common refuge. Raclet having found all the advantages of scalding, advised its use, preferably in March or April. According to the researches published by Terrell des Chênes, it has been definitely decided: (1) That scalding, even when applied ten years running, did no harm. (2) That it not only destroys *Pyralis*, but also many other insects of the vine. (3) That it also destroys the vegetable parasites of the vine, mosses, lichens, etc. (4) That it stops the growth of adventitious buds along the old wood which is a loss of sap for the stock and thus saves pruning. However, in spite of the excellent results, this method is practised very little, and that because it requires a litre of boiling water per stock, and it is not easy to use such large quantities in the middle of a field. For some years scalding of vines has become common by an improvement in the apparatus. The water is now heated in a portable boiler fitted with two lugs by which it can easily be carried. When the water boils the workman is warned by a whistle on the safety valve. He then fills a sort of tinned-iron coffee-pot holding a litre, and covered with cloth, or better still with a double jacket, so as to prevent cooling. The water must be at 80° C. (176° F.) at the time it touches the stock for the destruction of *Pyralis*, and 90—100° C. (194—212° F.) for *Cochylis*, so that it may penetrate the silky cocoons which protect the small grubs. To increase the temperature of the water carbonate of soda may be added; 5 or 6° C. (9—10·8° F.) extra are thus obtained which make up for the exterior cooling. In emptying the coffee-pot entirely on each stock the workman must act rapidly. He should with the drawn-out spout of the coffee-pot pour the hot water on the stock, rising in a spiral from the bottom, so that the water at the required temperature penetrates into all the interstices of the bark. The operation must be performed from below upwards, for if scalding was begun from the top of the stock the excess of water, perforce

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female lays its eggs in June on the surface of the cabbage leaves where these masses form plates of a white colour; the female of the second lays its separate eggs in packets.

cooled, would flow over the lower parts and fill the interstices; the boiling water poured afterwards would have no mortal effect on the insects on the bottom of the stock, because they would not receive it directly. This precaution is particularly necessary in treating old vines, because these are generally the refuge preferred by grubs owing to the roughness of the stock. Two workmen suffice to carry out the scalding; one feeds the fire and fills the boiler as the boiling water is drawn off, the other runs the hot water into the coffee-pots and pours their contents on the stocks. Working thus, 1500—2000 stocks can be treated per day. The boiler consumes about 200 kilogrammes (4 cwt.) of coal per day. To diminish the labour, large boilers are also used, with taps to which india-rubber tubing is attached ending in a nozzle, with intermittent jet. This nozzle which projects the water on the stock has the advantage of penetrating deeply into the cracks of the bark. This process, though preferable to others, is only used in large vineyards. Scalding should be done after the vintage when the grubs have taken refuge in the bark, and before they have assumed the chrysalis form, for the latter is not so sensitive as the grub. It is carried out as soon as pruning is finished and preferably in calm, fine weather. To combat the *Cochylis* it is necessary to operate in October or November, whilst the grub has not yet finished its cocoon; against the *Pyralis*, which remains all winter as a grub, proceedings can be taken all winter up to May before escape from the cocoon. In districts where props are used these are boiled by placing them in cases, into which steam is injected for eight to ten minutes, or by steeping them in boiling water for five minutes. Scalding carefully done with water at the temperature indicated is always efficacious, and has no injurious action on the vines if care be taken to perform it before the appearance of the bud. It is recognised that of all the treatments adopted against the *Pyralis*, scalding is still that which succeeds best. But it must be carried out with a certain regularity each year, otherwise the butterfly

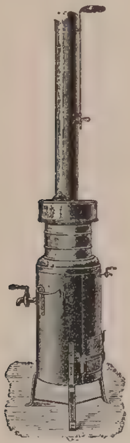

FIG. 3.—Portable Boiler.

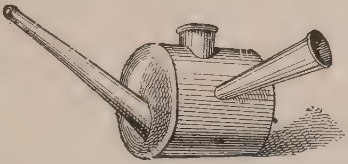

FIG. 4.—Coffee-Pot for Scalding Vines with Hot Water.

would again appear. This is the treatment which succeeds best against the *Cochylis*, provided it be done from October to November.

*Margantia histrionica*, Hahn (the red cabbage bug).—Murfeld has shown that these small bugs do not stand water heated to 65·5° C. (150° F.), a heat which does not alter cabbage leaves. Coccides [1] also suffer much from treatment with hot water. Reh found that generally they did not stand a great heat. Water at 54° C. (129·2° F.) kills them in forty minutes and water at 55° C. (131° F.) in twenty-two minutes; water at 60 –65° C. (140—149° F.) kills the apple coccis, *Aspidiotus ostreaformis*, and the pear coccis, *Diaspis piricola*, but most coccides stand a greater heat. The scalding of trees in winter is, therefore, an excellent method of freeing them from all these parasites.

*Tetranychus telarius*, L. (red spider).—In November this acarus takes refuge under the bark of the stock. The hot-water treatment can then be applied. The scalding executed as described above to destroy *Pyralis* can at the same time get rid of the red spider.

**Hydrogen Peroxide,** $H_2O_2$.—**Preparation.**—By decomposing barium peroxide by hydrochloric acid in the cold and then precipitating the baryta by sulphuric acid.

| $BaO_2$ | $+$ | $2HCl$ | $=$ | $BaCl_2$ | $+$ | $H_2O_2$. |
|---|---|---|---|---|---|---|
| Barium peroxide. | | Hydrochloric acid. | | Barium chloride. | | Hydrogen peroxide. |

**Properties.**—Hydrogen peroxide is a colourless syrupy liquid. A heat of 27—30° C. (80·6—86° F.) and light decompose it into water and oxygen. Aqueous solutions are very unstable but a small amount of sulphuric acid gives them stability.

**Use.**—The numerous applications of hydrogen peroxide in human medicine led to the expectation of good results in the treatment of plant diseases with this product. Hitchcock and Carleton tried hydrogen peroxide in solution of different strengths on the uredospores of *Puccinia*, but a solution of—

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[1] Coccides or Cochineals (plant lice, bark lice, scale insects, kermes).—These homoptera much resemble the "pucerons" by their manner of living. After hatching, these insects show great agility; then the apterous females fix themselves either on the young shoots, the leaves, or the trunks, sink their rostrum in the tissues and never move again. The body is ovoid, globular, and resembles a small excrescence of the bark. The female lays its eggs under this shell and dies, forming with its carapace a protecting shelter for its progeny. The most common are the following:—*Coccus of the Apple* (*Mussel scale*) (*Mytilaspis pomorum*), ( ? *Aspidiotus conchiliform*).—The shield resembles a small mussel shell. It attacks apple-trees. *Coccus of the Peach* (*Lecanium Persicæ*).—Very frequent on peaches in May and June. *Coccus of the Pear-Tree* (*Aspidiotus ostreaformis*) (the pear-tree oyster scale).—One of the most common, distributed on the branches of fruit trees, especially apple-trees, where it forms small greyish spots. *Coccus of the Pear-Tree* (*Diaspis piricola*).—Analogue of the coccus of the apple-tree; the coccus of the pear-tree has a red colour and not yellow like that of the apple-tree, a colour which is discerned by lifting the shield with the blade of a knife. *Coccus of San José* (San José louse) (*Aspidiotus perniciosus*).—It much resembles the preceding, and exercises its ravages, especially in America, on both fruit and forest trees. *Coccus, White, of the Lemon-Tree and Orange-Tree* (*Dactylopius citri*).—Its brown body is enveloped in a white waxy secretion; the trees attacked look as if covered with cotton. *Coccus, Red, of the Vine* (*Coccus Vitus or Pulvinaria Vitus*).—The red coccus of the vine has the appearance of a reddish-brown shell; at the time of laying, it secretes a whitish cottony substance which forms above the body a sort of cushion very apparent. *Coccus, White, of the Vine* (*Dactylopius Vitus*).—The white coccus of the vine, contrary to the red coccus of the vine, never fixes itself and lays its eggs several times.

TABLE IX.—*Result of Treating Puccinia Uredospores with Hydrogen Peroxide of Various Strengths.*

| | | | | | | |
|---|---|---|---|---|---|---|
| 0·1 | per cent. | acting during | 7 | hours | on spores of | *Puccinia graminis*, Pers. |
| 1·0 | ,, | ,, ,, | 17 | ,, | ,, | *Puccinia Rubigo vera*,[1] Wint. |
| 3·0 | ,, | ,, ,, | 14 | ,, | ,, | *Puccinia coronata*, Corda. |

far from destroying these spores rather favoured their development than otherwise.

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[1] *Puccinia Rubigo vera* (Rust, Spotted).—The uredo pustules formed on the leaves and the stems of cereals are more oval than those of the linear species. It is *the* rust of *wheat*, although it also attacks *rye* and *barley*.

# CHAPTER II

## HYDROGEN SULPHIDE—SULPHUR

**Hydrogen Sulphide (Sulphuretted Hydrogen,** $H_2S$).—**Preparation.**—By decomposing sulphides by a dilute acid. Iron sulphide is generally used. It is dropped in pieces into a Wolff's flask, two-thirds filled with water. By running in dilute sulphuric acid through a funnel there are produced (1) iron sulphate and (2) sulphuretted hydrogen, which is collected in a gasometer.

**Properties.**—Hydrogen sulphide is a colourless gas with the odour and taste of rotten eggs. It burns with a blue flame. It is very poisonous and treacherous, for it acts without any other warning than a bad smell. A small bird perished in an atmosphere which contained $\frac{1}{1500}$th; a horse does not live long in an atmosphere containing $\frac{1}{200}$th of this gas. Under its influence the globules of blood are unable to fix oxygen.

**Action on Plants.**—Hydrogen sulphide is also injurious to plants; in its presence the leaves are coloured with yellow spots, which entirely invade them, then the plants die. Schroder and Rems found that to be the case in the neighbourhood of factories which disengage a certain amount through their chimneys; gasworks amongst others, for coal gas always contains a certain quantity. An atmosphere only containing $\frac{1}{3000}$th of hydrogen sulphide, that is to say, an amount scarcely perceptible to the smell, but slightly blackening paper steeped in lead acetate, is poisonous to the plant. However, the toxic dose varies greatly with the species of plants. Even roots themselves are capable of absorbing it, and take a blue colour (Kny).

**Action on Insects.**—Mouillefert has examined the action of hydrogen sulphide on the phylloxera. On roots exposed in a flask filled with this gas these parasites died in three minutes, but whilst at the end of that time the adults were dead, the larvæ and the eggs did not appear to suffer. In an atmosphere containing 1 volume of $H_2S$ in 100 volumes of air the phylloxeras were found dead after twenty-four hours. If it contained 1 volume of $H_2S$ in 150 volumes of air it took forty-eight hours to destroy these lice completely. Now, as a litre of sulphuretted hydrogen weighs 1·5 grammes, an atmosphere containing 1 per cent. of this gas by volume only contains by weight 0·0015 per cent. of that acid. As that amount represents the limit of toxicity of this gas for the phylloxera, and as it requires 0·0016 gramme of carbon disulphide in 100 c.c. of air, it may be concluded that hydrogen sulphide is as poisonous to insects as carbon disulphide.

**Use.**—*Phylloxera.*—To utilize this property, therefore, of hydrogen sulphide, it only remains to discover a process capable of giving rise to the formation of this gas in the layers of soil round an infected vine. The alkaline sulphocarbonates fulfil this object. They decompose in the presence of moisture and acidity of the soil into alkaline carbonate and hydrogen sulphide.

$$\underset{\substack{\text{Potassium}\\\text{sulpho-}\\\text{carbonate.}}}{K_2CS_3} + \underset{\text{Water.}}{H_2O} + \underset{\substack{\text{Carbonic}\\\text{acid.}}}{CO_2} = \underset{\substack{\text{Potassium}\\\text{carbonate.}}}{K_2CO_3} + \underset{\substack{\text{Carbon}\\\text{disul-}\\\text{phide.}}}{CS_2} + \underset{\substack{\text{Hydrogen}\\\text{sulphide.}}}{H_2S}$$

Mouillefert tried ammonium sulphide, which acts perceptibly on the phylloxera in the same way as hydrogen sulphide. He buried around the roots, after having laid them bare, 500 grammes ($1\frac{1}{10}$lb.) per stock of a mixture of 36 parts of calcium sulphide and 66 parts of sulphate of ammonia. Under the influence of moisture these two salts dissolve in the ground, and yield by double decomposition ammonium sulphide and calcium sulphate. The result was negative.

*Melolontha vulgaris* (cockchafer).—The insecticide property of hydrogen sulphide has been utilized to destroy numerous injurious insects, living in the soil, especially the *white worm*. Dr. Precht has taken out a German patent to claim a process of formation of this gas in the soil. Prior thereto Roy had recommended the burying in the ground of cinders rich in iron sulphide. In Italy good results are obtained against the white worm by ploughing in white mustard, more especially mixed with one ton of gypsum per acre. The decomposition of these plants would appear to produce much sulphuretted hydrogen.

*Heterodera Schachtii*, Schm.—The ploughing in of crucifers and gypsum did not give the result expected.

*Coccides*.—Coquillet did not succeed in destroying the *coccis* of the lemon by covering this tree with an awning, and disengaging sulphuretted hydrogen under this improvised "cloche."[1]

**Sulphur,** S.—Sulphur, in combination with metals and metalloids, is very widely distributed in nature. It is chiefly met with as sulphides of iron, copper, lead, mercury, zinc, antimony, and arsenic. Native it is found in lacustrine deposits associated with marl, and especially in the precincts of volcanoes as a product derived from volcanic emanations. It is found in the mines of Vesuvius, of Lateria, near Rome, in those of Etna and Stromboli, beneath the marshes of Texas, Lousiana, and in other States of the U.S.A.

**Preparation.**—For agricultural purposes sulphur is prepared under different forms: (1) *Sublimed sulphur*, or *Flowers* of sulphur, is an extremely fine powder of a yellow straw colour, which, examined under the microscope, appears as small rounded grains, studded with small points. It often contains sulphurous acid and sulphuric acid in the proportion of 1 per cent. (2) *Ground sulphur* is obtained by the pulverization, grinding, and sifting of brimstone. Ground sulphur can now be obtained the fineness of which almost equals flowers of sulphur. It has the advantage of being neutral and cheaper. It consists of angular grains, and is paler than sublimed sulphur. (3) *Wind-blown sulphur* is of a bright colour, absolutely neutral, and can be passed through a 100 sieve, which proves that it is almost as fine as precipitated sulphur. It shows branching particles under the microscope and grains of regular dimensions. Like ground sulphur, it neither contains sulphurous nor sulphuric acid. It is dearer than ground sulphur. (4) *Precipitated sulphur* is impalpable. It is extracted from the spent material used for gas purification; when it is imperfectly purified it still contains tar, cyanides, and, as it is somewhat hygrometric, it burns the leaves. Hence its restricted use in the sulphuring of plants. It is obtained, also, by a chemical method: alkaline polysulphides, treated by hydrochloric acid in aqueous solution, give off hydrogen sulphide, and deposit at the same time a precipitate of almost white sulphur. This precipitated sulphur is dearer than the foregoing; it contains sulphuretted hydrogen and alkaline sulphides. (5) *Mixtures containing sulphur.*—In nature sulphur often occurs mixed with gypsum, carbonate of lime, sand, in proportions varying from 5 to 40 per cent. Such minerals are ground finely and marketed as Apt sulphur and Briabaux sulphur. The "Minerale Greggio," extracted in Sicily, is an earth containing 40 per cent. of sulphur, 2 per cent. of alkaline carbonate, 11·8 per cent. of carbonate of lime, 42 per cent. of magnesia, 36 per cent. of sulphate of lime, a little iron, clay, and arsenic. The value of these mixtures depends on their sulphur content; the gypsum and carbonate of lime have no anticryptogamic property. In many cases they are preferred, and that is what has contributed to the preparation of artificial mixtures containing 10–50 per cent. of sulphur only. The Fonta powder contains 10 per cent. of sulphur and 90 per cent. of talc. A marble worker of Saint-Beat, having tried a mixture of 50 per cent. of ground marble and 50 per cent. of sulphur, found that this very efficient treatment occasioned no scorching on the vine, even during great heat. Neutral mixtures have, therefore, been prepared for this purpose, containing 50 per cent. of sulphur and 50 per cent. of gypsum, carbonate of lime, or clay. Now that cryptogamic diseases, like mildew and black rot, have invaded the vine already attacked by oidium, attempts have been made to reduce the multiplicity of treatments by mixing sulphur with cupric powders. These powders, such as "Cupro-Calcite," will be dealt with when treating of oidium and mildew.[1]

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[1] *Note by Translator*.—But it must not be forgotten that sulphuretted hydrogen is heavier than atmospheric air in the proportion of 37 to 31, that is, 100 cubic inches of the former weigh 37 grains, and of the latter 31 grains. This difference in density must retard diffusion, so that the bottom of the plant would get an undue share and the top less than its share. Instead therefore of placing the generating vessel on the ground it should be at least well up the tree.

**Use.**—The use of sulphur goes back to 1846. It was by rule of thumb that the remedy was first discovered by the gardener Kyle, in experimenting in the greenhouses of Lyton with mixtures of sulphur and lime. At that time sulphur was already known as capable of curing mildew, and some gardeners used it. But when, in 1848, the oidium appeared, destroying the crops in the neighbourhood of Paris, J. B. Dumas, the Minister of Agriculture, ordered the disease known as *Oidium Tuckeri* to be examined, and the different remedies recommended to combat it to be tested. It was thus that Duchartre, Professor of Botany at the Agronomical Institute of Versailles, aided by Hardy, the gardener of the palace, undertook the study of the action of sulphur, and that he decided it to be efficient against the oidium. Gouthier, horticulturist at Montrouge, constructed at this time a bellows for sulphuring, which contributed much to spread the use of sulphur around Paris. Henceforth, owing to this use of sulphur it was possible to contend against the oidium, and in 1852 and 1853 the vines of Chasselas and Thommery were entirely preserved. Sceptical vine-growers, persuaded that the oidium could only develop on perishing vines, sought at the same time a remedy by improving the culture. There were long gropings in the dark, unsuccessful years, nevertheless, owing to the persevering efforts and profound study of Mares, a vine-grower of Herault, the action of sulphur on oidium was not long left in doubt. From 1857 sulphuring has spread more and more, and owing to this treatment oidium is no longer propagated to such an extent as to cause serious damage in vineyards. To contend against this disease France alone consumes 100,000 tons of sulphur per annum.

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[1] Mildew of the Vine. PERONOSPORA VITICOLA.—This fungus has great analogy with the *Phytophthora*. It prefers to grow on the leaves of the vine, but it also invades the young branches, the flowers, and the grapes. (*Brown* rot, grey rot, juicy rot.) The leaves begin to grow yellow on the attacked vines, then the spots are intensified and the vines assume a reddish-brown colour. This fungus lives between the cells and the parenchyma and on the under surface of the leaf emits conidiophora from which the conidia or summer spores are detached. These ripen in a night and germinate as soon as they fall on a leaf rendered moist by the dew or by the rain; they produce mobile zoospores. After a sojourn of half an hour in a drop of water, they fix themselves, emit a germinative tube which pierces the epidermis and penetrates into the interior of the leaf. Late in the season, winter spores are formed in the leaves which remain active and live in the withered leaves. In the spring the spores spread the disease. Mildew appears early in May and June.

**How does Sulphur Act?**—The different kinds of sulphur sold in commerce have not the same anticryptogamic value. In a general way that value is proportional to their pure sulphur content and to the fineness of division. Precipitated sulphur and blown sulphur are the products which attain the highest degree of fineness; sublimed sulphur and ground sulphur come very near them. In the manufacture of ground sulphur great progress has been realized of late years; formerly, in fact, it required 80 lb. to obtain a result analogous to that got from 40 lb. of sublimed sulphur, whilst now equal weights of these two products have the same anticryptogamic value. The adherence of the sulphur to the leaves depends on its fineness. From this point of view blown sulphur and precipitated sulphur are much superior to sublimed and ground sulphur, but the former are too dear. In extensive exploitations where they used sublimed sulphur almost exclusively, they have begun to replace the latter by ground sulphur, which has the advantage, like blown sulphur, of containing neither sulphuric acid nor sulphurous acid, and thus does not burn the leaves during great heat. To obviate the drawbacks which sublimed sulphur has of grilling the leaves and irritating the eyes of the operators, it has been ground with inert bodies capable of neutralizing the acids which it contains. Neutral mixings, with a much more gentle action on the plant, and which act in the same way as the neutral sulphur above described, are thus obtained. It is thus that mixtures containing gypseous, bituminous, calcareous ingredients are met with, which have at the same time the advantage of favouring adherence in rainy weather. Many preparations are used in the south of France, and in Algeria, where they are specially applied for August treatment; but a larger amount must be used in inverse proportion to the sulphur content. It was interesting to know the action of sulphur on fungi living as parasities on plants, and several scientists devoted themselves to this study. It is recognized that the destruction of the parasite is more rapid the warmer the weather. With a temperature of 30—40° C. (86—104° F.) destruction occurs in one to three days; from 25° C. to 30° C. (77—86° F.) it is already slower and takes four to five days; below 25° C. (77° F.) it is still more slow. According to Mach, Vesque, Sorauer, Hollrung and Dufour, this action of sulphur on the mycelium of fungi results from the formation of sulphurous acid, formed by the slow combustion of sulphur under the action of the sun and heat. Pollacci, on the other hand, believes that the sulphur is transformed into sulphuretted hydrogen, the vapours of which have a very energetic action on fungi. The third opinion is that of Mares and Mohr, who believe that the sulphur acts of itself, *i.e.* by its own vapour. The first hypothesis seems in fact inadmissible, for the simple reason that the sulphur cannot be transformed into sulphurous acid except at high temperatures and only by its combustion. But the sulphur does not act only on the mycelium of the fungi where it is in contact with it; sulphur placed at a distance acts equally well. Spread on the soil around the plant, it acts perfectly well if the temperature reaches 25—30° C. (77—86° F.). This observation was noted as regards greenhouses by Bergmann, Lord Rothschild's gardener, and by Viala, for vines in the open air. If it be therefore recognized that sulphur acts by the vapours which it emits, the nature of such vapours remains to be examined. Sulphurous acid must not be dreamt of; $\frac{1}{40000}$th of this acid in the air would burn the leaves. In warm and cold greenhouses where the plants are unceasingly exposed to the vapours of the sulphur emitted from the sulphur spread on the soil, these would not resist long if the ambient air contained sulphurous acid. The effects of this acid, to be examined further on, are disastrous to plants, and if it be admitted that sublimed sulphur burns plants, this drawback is only due to the presence of sulphurous and sulphuric acids. The formation of sulphuretted hydrogen is equally impossible. To determine what the nature of the vapours emitted from sulphur when it is spread on the leaves and the soil and exposed to the action of the air and the sun may be at temperatures of 25—40° C. (77—104° F.), the author (Bourcart) made a series of laboratory experiments. Sulphur mixed with dry or moist soil with or without humus was placed in flasks with a tubulure. After having arranged these flasks on a water-bath heated at 35—50° C. (95—122° F.), pure oxygen or a simple current of air was passed over these mixtures and the experiments were kept up for eight days. At the exit from the flasks the gas passed through a series of bottles containing substances to retain sulphurous acid in some, hydric sulphide in others. Analyses made of the liquids collected and of the soil mixed with sulphur gave no trace of sulphurous acid, nor of hydrogen sulphide, hyposulphite, or sulphuric acid. Between 25 and 50° C. (77—122° F.) therefore sulphur undergoes no chemical modification, and if it acts at this temperature on fungi it is by its own vapours. The odour of a greenhouse or a vineyard is in fact never that of sulphurous acid or hydric sulphide but that of sulphur.

There is another reason in favour of the sulphuring of vines. Sulphur would appear in fact to have a direct action on vegetation which it renders more vigorous; it favours fecundation and otherwise stimulates the maturity of the grape which generally ripens eight days earlier. It is therefore advantageous to sulphur the vine even in the absence of cryptogamic parasites.

Recent experiments (1924) on the fungicidal action of sulphur in the U.S.A. have shown that sulphur is toxic only in the presence of oxygen, that the active principle is volatile, and that precipitated sulphur is more toxic than finely ground sulphur. Young, as a result of his extensive researches on the toxic property of sulphur, concludes that toxicity is exhibited only when oxygen and water are present and is due to the formation of pentathionic acid, a volatile oxidation and hydration compound of sulphur. Finely divided sulphur is more readily oxidized to pentathionic acid than flowers of sulphur—a fact which explains the greater effectiveness of colloidal sulphur. Wettable sulphur sprays have been found somewhat difficult to prepare, as the sulphur alone refuses to mix with water; a formula recommended in Nova Scotia is about 67 per cent. superfine sulphur, 30 per cent. hydrated lime, and 3 per cent. calcium caseinate, this mixture to be used at from 30 to 50 lb. per 100 gallons, with the addition of 2 lb. lead arsenate. The ingredients should be mixed beforehand in a dust mixer. This mixture is said to cost about the same, or very little more than the standard 3 : 10 : 40 Bordeaux, is quite harmless to foliage or fruit, and is superior in the control of all insects.

The usual distinction made between precipitated (hydrophobic) sulphur and a true hydrophilic colloidal solution is largely in the size of the particle. The latter is made by passing hydrogen sulphide through a saturated solution of sulphur dioxide until the odour of the latter cannot be distinguished. This is important, as if free sulphur dioxide remains in the solution it is apt to scorch foliage. This is a stable preparation, in which the particles aggregate but slowly. Hydrophobic colloidal sulphur is prepared by precipitating lime-sulphur solution by adding concentrated hydrochloric or sulphuric acid. The acid was added to the solution to a point of acidity as shown by methyl orange, about 0·5 c.c. concentrated acid per 10 c.c. of lime-sulphur concentrate (1·3° Bé.) being usually required. Such solutions tend to aggregate sulphur particles up to a point of precipitation within a few days. Glue or gelatine delays this process, especially if added before the acid. For commercial purposes 1 lb. of glue dissolved in water is first added to 5 U.S. gals. lime-sulphur solution, then in addition, 2 to 4 U.S. pts. of concentrated acid, or until the yellow colour disappears and the solution is slightly acid to methyl orange. A larger amount of glue is required if the solution is to stand several days before use. In these preparations the sulphur particles are so finely divided that they are invisible at a magnification of eighty times and are more active than the finest of ground or flowers of sulphur now in use.

Toxicity tests with the U.S. red spider (*Bryobia prætiosa*) show that colloidal forms of sulphur killed about 99—100 per cent.; 2 per cent. lime-sulphur solution plus 5 lb. ground sulphur per 100 U.S. gals. killed 90·6 per cent.; ground sulphur dust killed 44·9 per cent. These applications were made in June, the maximum temperatures of the days following them being 71–78° F. At higher temperatures the differences were less marked, but even then the colloidal forms were always superior. Colloidal forms of sulphur, particularly the hydrophilic solution, are more dangerous to foliage even than lime-sulphur solution. Under California conditions, where most of the work on red spider is done at high temperatures, it is doubtful if colloidal solutions could be economically substituted for lime-sulphur solution containing free sulphur, at least until an inexpensive process of manufacture is established.

**How Should Sulphur be Applied?**—Sulphur is generally used as a curative agent, and sometimes as a means of prevention. There is no absolute rule for applying sulphur, the essential point is to do it at the right time. The adhesion of sulphur can, in fact, be increased by applying it when the plants are still covered with dew, or after artificial moistening, but that is not indispensable, for dry sulphur generally adheres well enough on the leaves, and chiefly on the diseased parts. The mycelium of the *Erysipheæ* retain, in fact, lumps of sulphur, which persist longer on the spots attacked than on the healthy spots. If a persistent rain comes on or a storm in twenty-four hours after sulphuring, it is well to repeat the operation. Sulphuring may be done at any hour of the day. The dose of sulphur should suffice to cover entirely the diseased parts. During great heat it suffices to spread the sulphur on the ground at the foot of the plant. Sulphuring has been used preventively in greenhouses to prevent all cryptogamic diseases from appearing. The sulphur is spread on the soil, or on the heating pipes once a year. The plants thus live in a special atmosphere containing sulphur, which is opposed to the development of fungi, without injuring the plant. Different utensils have been used to spread the sulphur. The most simple is a vessel of tinned iron, the bottom of which is perforated. It is filled with sulphur and shaken above the diseased plant. This instrument, however, much used in the south, has the drawback of spreading the sulphur very irregularly, and in too large quantity on the diseased plant. Another type is constructed on the same style, but it contains meshes of wool which sift the sulphur and distribute it more regularly. But these primitive instruments have been almost everywhere replaced by bellows or blowers. The first was constructed by Gonthier, and greatly helped to popularize sulphuring. This is the bellows still used in gardens. It consists of a box to contain the sulphur, which is fitted with a flat pipe at one of its extremities and an ordinary bellows at the other. For large vineyards there is a more practical instrument, which carries a larger quantity of sulphur. It is a sort of *hood*, called a *soufreuse*, which the workman places on his back, and which can contain 10—12 kilogrammes (22—26·4 lb.) of sulphur. It is filled by an air-pump, with fan, which is wrought by a lever and a projector, the extremity of which, ending in a Raveneau jet, distributes the sulphur as a mist. It can treat 1—2 hectares (2½—5 acres) a day. It must be perfectly cleaned after each operation, so that the sulphuric acid of the sulphur does not damage the metal part. The action of the sulphur on the *Erysipheæ* is unquestionable, the mycelium of which, crawling on the surface of the organs attacked, is quickly disorganized. All the mildews may therefore be effectively overcome, and it suffices for the purpose to sulphur at each approach of these parasites. But the use of sulphur does not stop there. In certain cases, in fact, where the mycelium cannot be destroyed, as the plant itself protects it, it destroys the external organs of fructification, such as the *Conidiophoreæ*, and prevents the disease from assuming too great an extension by that alone. It is thus that sulphur acts on certain *Peronosporeæ* [1] and *Black blights*. Diseases of a bacterian nature may sometimes be contended against preventively by the disinfection of the seed by sulphur. Sulphur also acts energetically on certain insects with a soft skin, and, according to Berlise, its action is rendered more efficient by steeping it in wood tar and then drying it. It has been found, however, to have no action on plant lice or cochineal.

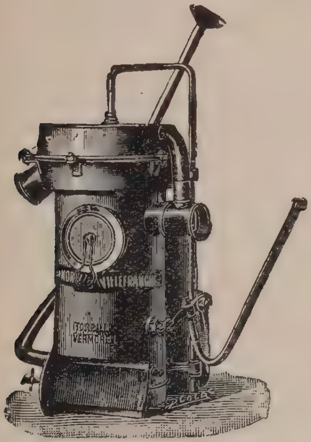

FIG. 5.—Torpedo Sulphur Distributor.

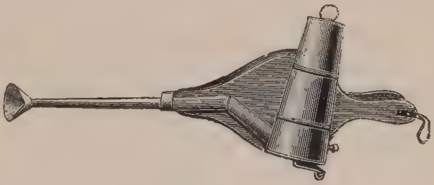

FIG. 6.—Regulator Sulphur Bellows.

**Use against Bacteria.**—Amongst the bacterian diseases of plants the following can be treated with sulphur :—

*Rottenness or Moist Gangrene of the Potato* [2] ; *Potato Scab* [3] ; *Rottenness of the Sweet Potato* (*Batates edulis*).—Nijpels and Stone recommend the use of sulphur preventively against these diseases. They advise that the potatoes intended to be planted be rolled in flowers of sulphur after being completely moistened so that the flowers of sulphur adhere more completely. They also recommend flowers of sulphur to be spread in the furrows in which the potatoes are planted. Halsted estimates that manure with 170 kilogrammes of sulphur per hectare, say 150 lb. per acre, especially if it be accompanied with a manuring of 175 kilogrammes per hectare (154 lb. per acre) of kainit, gives results quite as satisfactory as the usual disinfection of the tubers by corrosive sublimate. Nijpels, who controlled these experiments, found, however, that his own process gave a better result.

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[1] PERONOSPORA (mildew and white rust).—Fungi of which the mycelium lives in the interior of the tissues and which produce on the surface of the attacked organs whitish tufts resembling blights.

[2] ROT OR MOIST GANGRENE OF THE POTATO.—This disease is a complete disorganization of the plant which is attributed to the action of the *Bacillus amylobacter* (Kramer) and according to American specialists to the action of *Oospora scabies* (Thaxt).

[3] POTATO SCAB.—This is due to the growth of an aerobic bacteria in the living tissues of the circumference of the tubers.

**Use against Fungi.**—Amongst the *Peronospora* we may quote *Cystopus candidus*,[1] Lev. (white rust of the *Cruciferæ*); *Cystopus cubicus*,[1] de By. (white rust of the *Compositæ*). The sulphuring recommended by Weiss to combat white rust can have no effect, except preventively, at the time of lifting the seed. Then several sulphurings are applied, working preferably in the morning during the dew.

*Uredineæ* (rusts injurious to cereals).—Sulphur has no action on these diseases, the mycelium of which grows exclusively in the body of the nurse plant, and the spores of which are generally formed under the epidermis of the plant. Amongst the *Erysiphe* we may quote *Erysiphe communis*, Wallr. (mildew of the pea and bean). We can efficiently contend against this fungus, either by the use of sulphur or of sulphur and lime. Prillieux holds that sulphuring done as soon as the first spots appear may completely save the crop invaded. In the same category the most important of all the diseases, that which has caused the greatest ravages, is, without doubt, the disease known under the name of *Uncinula americana*, How. (oidium of the vine). Since the decisive researches of Mares, vine-grower of Herault, it has been possible owing to the use of sulphur to contend victoriously against this plague without, however, causing it to disappear completely. It is quite as lively as when it first appeared, but by the rational application of sulphur its development can be circumscribed and its action on crops prevented. The disease always assumes new vigour when vine-growers are negligent in the execution of this treatment. But so that the latter may be absolutely efficient, it must be practised in special conditions. It is evidently difficult to fix in a precise manner for all regions the number of sulphurings to apply and the proper times, so as to protect the vine from invasion. Moisture and heat are, in fact, important factors of the development of the oidium; the questions of climate, of exposure, of the year itself, have a great influence on the time of treatments and their number. There are two methods of sulphuring vines: (1) *The repressive method*, which consists in sulphuring each time the disease appears on a certain part of the vine. That requires great attention on the part of the vine-grower, who should not let the disease extend too far. (2) *The preventive method*, which is most in use, consisting of three sulphurings at fixed intervals. The first sulphuring is applied when as yet no oidium has been observed at the time when the young branches reach 8—10 centimetres (3·2—4 inches) in length. The second at the time of flowering, and the third some days before *veraison*, taking care to sulphur the grapes chiefly. A supplementary sulphuring may be intercalated between the second and the third if special conditions are favourable to the reappearance of the disease at that moment. Dufour advises two treatments before flowering, the first, before the complete expansion of the leaves, the second a little before flowering. Spring sulphurings in no way injure the plant, and they may be executed at any hour of the day. But those which must be made in the hot season may injure the vines, the leaves of which are burned by the sulphur under the action of the sun. It is then necessary to comply with the following indications :—

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[1] RUST, WHITE, OF CRUCIFERÆ. *Cystopus candidus*. RUST, WHITE, OF COMPOSITÆ. *Cystopus cubicus*.—The hyphæ of the mycelium of these diseases glide between the cells of the nurse plant and there sink their suckers. The conidiophora form white pustules which are found indifferently on the surface of the leaves, stems, flowers, and fruit, for the fungus invades all the plant and causes it to undergo very curious deformations.

(1) To use neutral sulphurs, chiefly mixtures, containing but little sulphur, instead of flowers of sulphur, always slightly acid, and because the former have a much more gentle action than pure sulphur. (2) To spread the sulphur preferably on the soil, instead of projecting it directly on the plant. This process is not only efficient, but without the drawbacks described above (Viala). When these few precautions are neglected, a large part of the crop is liable to be lost, owing to the corrosive action of the sulphur. The dose to apply at each sulphuring depends on the state of growth of the vine and the system of planting. For the first treatment it is well to use 15—20 kilogrammes (33—44 lb.) of flowers of sulphur per hectare (13·2—17·6 lb. per acre). At the time of flowering the dose is raised to 30 kilogrammes of flowers of sulphur (66 lb. per hectare, 26·4 lb. per acre) or 50 kilogrammes (110 lb. per hectare, 44 lb. per acre) of ordinary ground sulphur. Finally for the third operation it is necessary to spread 40 kilogrammes of sublimed sulphur (88 lb. per hectare, 35·2 lb. per acre) or 60—70 kilogrammes of ground sulphur per hectare (52·8—61·6 lb. per acre) and about 100 kilogrammes of Apt sulphur (220 lb. per hectare, 88 lb. per acre). When the ground sulphur is as fine as the sublimed, the quantity to use will be the same as for the latter. To preserve hothouse vines, it suffices to spread sulphur on the soil once a year; any invasion is prevented by this single treatment. Since other cryptogamic diseases—mildew, black rot, and others—have ravished the vine, attempts have been made to reduce the multiplicity of treatments, and cupric powders have been mixed with the sulphur, the isolated action of which is recognized as efficacious against these diseases. It has been advised to add 5 per cent. of blue vitriol to the sulphur, or to incorporate sulphur in the cupric bouillies. A preparation known under the name of "cuprocalcite" has in Germany the reputation of being at 25° more active than sulphur (Mohr). This product would appear to form a protective coat on the leaves, and by its adherence preserves the plants longer against new invasions of oidium. But this opinion is not accepted, and it is generally believed that sulphur does not act in the presence of common salt. Pollacci and P. Viala condemn these mixtures, the first, because he believes that sulphur is not oxidized in the presence of copper salts, the second, because the experiments made at the Montpellier schools showed that these mixtures could neither prevent nor arrest the oidium and mildew. Mach and Mares agree upon that point, and this is the explanation : Copper salts have, in fact, the drawback of catching the vapours of sulphur, converting

them into insoluble and inactive copper sulphide. If it be taken that sulphur acts by its vapours, it is evident that the action of the product is destroyed. These remarks are also of value in regulating the double treatment with sulphur and cupric bouillies. Since the introduction into viticultural practice of sulphating against mildew and black rot, the question of ascertaining whether sulphuring should be done before sulphating, or *vice versa*, has been often discussed. Laurent advises to precede the first sulphuring by the first sulphating, the second sulphating being done after flowering. But as the sulphur acts for four to five days, it is well to let this interval elapse between sulphuring and sulphating, so that these two treatments do not mutually destroy the effects of each other.

**Drawbacks to Sulphuring.**—Workmen engaged in sulphuring with sublimed sulphur sometimes have bad eyes, especially if they do not take the precaution to work with the back to the wind. To obviate this drawback, it is well to make them wear spectacles with cloth side-pieces, and to make them bathe the eyes several times a day with fresh water. Sulphur also gives sometimes a slight taste to the wine, owing to hydrogen sulphide, formed during fermentation. But this drawback is always caused by too dilatory sulphuring. If the wine still contains sugar, and is fermenting, it must be drawn off after fining in a cool cellar. If it does not contain sugar and is already drawn off, it must be protected from any new production of hydrogen sulphide by the following treatment: In the case of wine with a feeble taste, one or two drawings off, during which the liquid is allowed to flow in a thin stream into a tank, may suffice to let the hydrogen sulphide escape into the air. L. Mathieu advises running the wine in a stream over a plate of polished copper, so that it runs into a film: one part of the gas escapes into the air, the other is fixed by the copper. The copper plate must be cleaned from time to time with emery paper when it is blackened. If these methods do not suffice, sulphurous acid must be added to the wine as bisulphite of potash (metabisulphite of potash), about 10 grammes per hectolitre, say 7 grains per gallon. The two gases mutually destroy each other with the deposition of sulphur, which simple fining after a few days will completely carry down into the lees. By using for the last operation only 40 kilogrammes of sublimed sulphur per hectare (35·2 lb. per acre) or a stronger dose of Apt sulphur or any other product of low sulphur content, this drawback need not be feared.

*Oidium fragariæ*, Harz (oidium of the strawberry).—Sulphuring gives excellent results (Sorauer); *Phyllactinia suffulta*, Rebent. (mildew of the hazel and the ash-tree); *Microsphæra grossularia*, Wallr. (mildew of the gooseberry leaf).

*Sphærotheca Castagnei* (mildew of the hop).—Nijpels recommends to fight it, like the oidium of the vine, by three sulphurings, the first before flowering, the second during flowering, and the third when the cones are completely developed.

*Sphærotheca pannosa*, Lev. (mildew of the rose and the peach).—By methodical sulphuring, applied as soon as the disease appears, the rose bushes, most sensitive to this mildew, may be quickly cured. The curative treatment of the peach miller (*meunier du pecher*) also consists in two or three sulphurings applied after ten days' interval.

*Fumagine* (smut of fruit trees).—Sulphur has the same action on capnodium as on mildews, but to be completely successful it is necessary to fight the lice and the cochineal, which are the first cause of the fumagine. Amongst the *Sphæraceæ* capable of being fought with sulphur there may be mentioned :—

*Dematophora necatrix* [1] (white root rot of vine, etc.).—Narbonne has tried sulphur against vine rot. He advises to pull up the most badly attacked stocks; to lay bare the stocks not so badly attacked as deep as possible, and dust the roots abundantly with sulphur. It is useful to renew this operation several times before the stocks are covered up again.

*Black Blights*, the mycelium of which is in the interior of the plant, are more difficult to reach by sulphur, but as their organs of fructification, the conidiophores, are formed on the surface of the leaf, those organs can be got at by sulphur. The propagation of the disease is thus fettered. In this class are :—

*Sphærella fragariæ*,[2] Sacc. (spots of the leaf of the strawberry).—This very common and often harmless disease may, when it is intensely severe, stop the development, and entail the death of the plant. Nijpels recommends sulphur mixed with lime to prevent the disease on young plants.

*Septoria petroselini*, Dmz. (var. Ap. Br. et Cav.), injurious to celery, is fought by sulphuring, like the *Cercospora apii*.

*Gloeosporium ampelophagum*, Sacc. (grape rot).—This disease may be fought by sulphuring, but to succeed it must be applied in the beginning of the attack, so as to hinder the germination of the spores. To stimulate the action of the sulphur it is mixed with pulverized iron sulphate or lime. P. Sol advises a very abundant first sulphuring before flowering, to distribute them plentifully in the same spots, and then to sow ferrous sulphate broadcast, 50 kilogrammes per hectare (44 lb. per acre). If the epidemic be not arrested it is necessary to renew this treatment. Viala obtained good results from mixture of sulphur and lime applied in the following proportions :—

TABLE X.—*Showing Proportions of Sulphur and Lime used in Mixtures against Anthracnose* [3] *at Different Stages of Treatment.*

| | First treatment. | Second treatment. | Third treatment. |
|---|---|---|---|
| Sulphur . . . . | 4 parts | 3 parts | 2 parts |
| Lime . . . . | 5 ,, | 2 ,, | 3 ,, |

The first treatment is applied when the shoots are 8—10 centimetres

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[1] DEMATOPHORA NECATRIX (white root rot).—This fungus lives at the expense of the roots of the vine, fruit-trees, mulberry-trees, fig-trees, maple-trees, oak-trees, and soon kills the tree. The white root rot is especially attributed to the *Sphæriaceæ dematophora*, but this fungus is not the only one capable of producing this physiological condition of fruit trees.

[2] SPHÆRELLA FRAGARIÆ (spots of the leaves of the strawberry).—The leaves attacked by this fungus are covered with purple-brown rounded spots, separate or contiguous, which appear on their upper face. They increase rapidly in size, wither in the middle, and are finally pierced right through.

[3] ANTHRACNOSIS OF THE VINE (grape rot). *Gloeosporium ampelophagum.*—The filaments of this fungus live inside the cells and produce spots on all the herbaceous parts of the vine, each forming small ulcers gnawing the tissue as far as the soft parts of the liber. The branches are contorted and blackened.

(3·2—4 inches), the succeeding treatments every fifteen days. Briosi tells us that this sulphur and lime treatment is in actual use to fight anthracnose in the provinces of Pavia, Cuneo, and Messina. Solutions of sulphate of iron are reserved for winter treatment.

*Cercospora apii*, Fr. (celery leaf blight).—Sturgis, Duggar, and Baily agree as to the efficacy of sulphur in fighting this disease when applied on a hot day, in which case sulphur is superior to all other chemical agents. Scribner dissents, and asserts that sulphur has little or no action. It is evident that sulphur cannot reach the fungus developed in the interior of the leaf, but in destroying the organs of fructification it may stop the propagation of the disease.

*Cladosporium fulvum*, Cooke (tomato leaf rust).—Mohr and Nijpels found that sulphur acts more effectively than copper salts to arrest this disease.

*Clematite* (large flowered), variety of *Clematis patens, lanuginosa et florida, disease of.*—This disease, to which many fine ornamental plants succumb, is attributed to the *Aecidium clematidis* or *Aecidium englerianum*, sometimes to *Nematodes*. The clematites disease cannot be circumvented by copper salts. But Fourrat found it possible to prevent it by laying bare the root, which he dusted with sulphur and afterwards covered with soil. The author's (Bourcart) experiments did not confirm this result.

**Use of Sulphur against Insects.**—*Crioceris asparagi*,[1] L.—Miss Ormerod killed these insects by a spray consisting of 1 lb. of soap, 1 lb. of sublimed sulphur, and 1 lb. of soot, in 10 gallons of water.

*Haltica nemorum*, L. (earth flea).—These minute Coleoptera gnaw the leaves of young plants, and, owing to their numbers, cause great damage. Their destructive work may be stopped by dusting the plants, whilst still small, with a mixture consisting of 3 kilogrammes (6·6 lb.) of sublimed sulphur, 5 kilogrammes (11 lb.) of soot, and 50 litres (1¾ bushels) of quicklime per hectare (2½ acres). In the author's opinion the quicklime would have a preponderant action.

*Haltica ampelophaga*, Guer. (altise of the vine [2]).—D'Aurelles de Paladines proposes to fight them with sublimed sulphur, or better, precipitated sulphur from gasworks. A more energetic method consists in using a mixture of black snuff, 12—15 kilogrammes, and Apt sulphur, 85—88 kilogrammes per hectare (10·4—13·2 lb. and 74·8—77·4 lb. per acre). A mixture of Apt sulphur and newly slaked lime may also be used.

*Ephippigera bitterensis* (*Ephippiger of Beziers*), *Ephippigera vitium* (vine ephippiger).—These grasshoppers devour the leaves, the young vine shoots, and the grapes. The crop is sometimes seriously compromised in the South of France by the great number of these Locustides. The grapes may be protected from their voracity by dusting the bunches in June, at the time when the Ephippigeres appear, with a mixture containing equal parts of sulphur and lime.

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[1] CRIOCERIS ASPARAGI (asparagus beetle).—Coleoptera (chrysomelide) of 6 millimetres in length, steel blue elytra, with four bright yellow spots.

[2] ALTISE OF THE VINE. *Haltica ampelophaga* (vine flea).—Small greenish-blue insect, 5 millimetres. The female lays its eggs at the end of April on the under surface of the leaf, the larvæ appear ten days afterwards; they burrow long grooves into the parenchyma; in ten days they reach full size, let themselves drop on the soil and there bury themselves to the depth of 2 inches; two weeks afterwards the perfect insects appear.

*Eriocampa adumbrata* [1] (slug worm, or slimy caterpillar of pear-tree saw-fly).—Goethe recommends ground sulphur against the sticky larvæ of this saw-fly. This treatment is in common use in the Tyrol.

*Carpocapsa pomonella*,[2] L. (codlin moth), the grub of which renders apples wormy. The sulphuring of apple trees, after flowering, is very efficient in drawing off the butterfly and preventing it laying its eggs on the young apples.

Success has been obtained in the U.S.A. with the wettable sulphur sprays, against codlin moth (*Carpocapsa pomonella*) and red bug (*Heterocordylus malinus*). The formula was 4 lb. hydrated lime, 8 lb. sulphur and 1½ lb. powdered lead arsenate to 50 U.S. gals. of water, with 1 lb. calcium caseinate or 4 ozs. glue per 100 U.S. gals. as a spreader. While on the average not quite so effective as lime-sulphur solution in controlling apple scab, these sprays have proved safer on apple foliage.

*Phylloxera vastatrix* (phylloxera of the vine).—Two processes have been used; that of Saintpierre, tried unsuccessfully, is quoted as a matter of history. It consisted in making a hole in the vine with a gimlet and in introducing 3 grammes of sulphur, then in re-closing the hole with a plug. The second process, that of Aman-Vigie, consisted in injecting into the soil, by means of a special bellows, a mixture of sulphur and sulphurous acid. But these vapours do not diffuse well in the soil and only penetrate it imperfectly. Henneguy, after trying this process, concluded that, applied in July and August, it exerted an unfavourable action on the propagation of this insect. If it be not capable of entirely freeing the vine from its parasite, it kills a sufficient number to allow the plant to live normally.

**Use against Acari.**—*Tetranychus telarius*, L. (red spider so-called).—In hothouses it may be fought with sulphur. Maynard advises heating the sulphur in a pot till it gives off fumes without inflaming. This operation should be renewed two or three times a week for several months. Sturgis asserts that this process destroys at the same time the *Peronospora*, de By., which resists repeated sulphurings in the open air.

*Tetranychus bioculatus*, W.M. (red spider of tea).—Playfair recommends to destroy it to spread on the tea before cutting 50 to 60 kilogrammes of sulphur per hectare (44—52·8 lb. per acre).

*Eriophyes vitis*, Land., syn. *Phytoptus vitis* (erinosis [3] of the vine).

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[1] ERIOCAMPA ADUMBRATA. *Selandria atra* (the slug-worm or slimy caterpillar).—Saw-fly, of a brilliant black with a transversal brown band on the upper wings. The larvæ are first of a blackish-green, then of an amber-yellow and covered with a viscous substance; it vaguely resembles a small snail, hence the name slug-worm. They devour the parenchyma of the cherry-tree, the pear-tree, the plum-tree, and the apricot-tree.

[2] CARPOCAPSA POMONELLA (pyralis of the apple-tree) (apple-worm, codlin moth).—Moth of ½—1 centimetre long, ashy-grey wings striped crosswise with small dark sinuous lines, with bronze reflex lustre and marked at the extremity with a brown spot encircled by a gilded yellow line. After fecundation the female lays its eggs one per fruit on the epidermis of the new-formed fruit and on the surrounding leaves.

[3] ERINOSES. *Phytoptides* (gall mites).—The irritation caused by the bite of certain acari, the Phytoptes, causes alterations in the epidermal cells of the leaves

—Erinosis may be arrested by repeated sulphuring, commencing some time after the formation of the buds, when the branches are 8—10 centimetres (3·2—4 inches) in length. Couderc advises a hot day in spring for the operation.

*Eriophyes malinus*, Nal., syn. *Erinium malinum* (erinosis of apple and pear).—Sulphuring applied from bottom to top produces a satisfactory effect.

*Eriophyes piri*,[1] Pgst. C. (brown rust of the pear), syn. *Phytoptus piri*.—Repeated sulphurings are efficacious if applied before the appearance of the disease.

*Phyllocoptes Schlechtendali*,[2] Nal. (browning of leaves of pear and apple trees). This fungus is readily attacked by insecticides, and sulphur acts in a sure manner.

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which elongate under the form of hairs and form a felt, generally in the lower part of the leaves, which may be white, yellow, rose, or rust colour. These diseases are widespread. ERINOSIS OF APPLE-TREE AND PEAR-TREE. *Erinium Malinum et Pirinum*.—Felting of under part of leaves, passing from yellow and rose to rust colour. ERINOSIS OF THE GOOSEBERRY. *Phytoptus ribis*.—This acarus sucks gooseberry buds and leaves; the branches never develop and form packed branches of leaves. ERINOSIS OF THE VINE. *Phytoptus vitis, Eriophyes vitis*.—Leaves attacked by this Phytoptus show irregular-shaped swellings on the upper surface, and are coated on the under surface with down. White at first, the down becomes red, then brown, as it ages.

[1] ERIOPHYES PIRI. *Phytoptus piri* (rust of the pear-tree).—This disease is produced by an acarus which dwells in the parenchyma of the leaf and circulates between the two epidermes. The irritation of its bites causes the formation of pustules, the red tint of which on the young leaves becomes brown and even black in a few weeks.

[2] BROWNING OF THE LEAVES OF THE PEAR-TREE AND APPLE-TREE. *Phyllocoptes Schlechtendali*.—The acarus which produces this browning lives freely on the surface of the leaf; it neither produces galls nor felting.

# CHAPTER III

## CARBON DISULPHIDE, $CS_2$

**Carbon Disulphide.—Preparation.**—By passing the vapour of sulphur over red-hot charcoal. On the large scale, vertical cast-iron cylinders built in masonry are used. They are filled with charcoal, which is kindled. As soon as it has reached a sufficient heat, the sulphur is introduced, gradually, through a side pipe. The sulphur melts, then vaporizes, and combines as vapour with the incandescent carbon. The gas escapes through a top pipe which communicates with two reservoirs, the first of which retains entrained sulphur, the second, which is cooled by a bath of cold water, condenses the vapours of carbon disulphide. The uncondensed gases, which are hydrocarbons, escape through a top pipe. Carbon disulphide flows into zinc reservoirs, where it is preserved under water. It may be rectified by drying it over fused calcium chloride and finally distilling it on a water-bath. For agricultural purposes, this rectification is useless; carbon disulphide in that case is led directly from the tank into the wrought-iron barrels, in which it is dispatched. Another method of preparation is by heating carbon with sulphur in an electric furnace and condensing the $CS_2$ vapours.

**Properties.**—Carbon disulphide is a colourless liquid with a pleasant smell when it is pure, but almost always fetid on account of impurities which it contains. It is a very mobile liquid, which boils at 45° C. (123° F.), and consequently vaporizes with rapidity in an open vessel. Its vapours form with air mixtures capable, like coal gas, of detonating at the approach of a flame or an incandescent object. Owing to its ready inflammability the manipulation of carbon disulphide necessitates great precautions, and should be carried out far from any source of heat or flame, and wholly in the open air. Smoking is therefore forbidden in the sheds where it is handled, and when it is employed in the field the iron barrels containing this product should be deposited far from dwellings, and protected from the sun. To prevent the losses which would result from the evaporation from a cask being emptied, a good precaution is to run a small quantity of water into the cask. The water forms on the surface of the carbon disulphide a protecting layer, for the density of the water is lower than that of the sulphide. To ascertain the quantity of this liquid left in a barrel, a rod coated with tallow may be dipped into it. The rod will come back clean on all the part which touched the carbon disulphide, this product being a solvent for all fats. Carbon disulphide is almost insoluble in water; the latter can dissolve at 1000th part of its weight. On the other hand, it is miscible, in all proportions, with absolute alcohol, and with a great number of organic bodies rich in carbon, such as fats, resins, camphors, greases. It exercises a very decided deleterious action on the animal economy; it produces headache and nausea, and after a certain time it may debilitate the nervous system. Its intoxications are not generally dangerous, for they cease by the simple removal of the cause. The workmen who handle this product are subject to its effects if precautions are not taken to protect them from the vapours; those suffering from heart weakness should avoid it altogether. Carbon disulphide is used in medicine as an antiseptic against typhus, cholera, tuberculosis, against cancers, intestinal catarrh, and especially infectious diarrhœa, finally as an emmenagogue and anæsthetic. In the form of vapour it is used against helminthiasis and different diseases of the skin.

**Action of Carbon Disulphide on Plants.**—Carbon disulphide is poisonous to plants. According to Sandsten it stops the movements of the protoplasm as soon as the plant comes in contact with even a very small dose of this agent. It is more injurious to the plant the more its application corresponds with a greater activity of the sap. The same doses used in winter without prejudicing the plants may become deadly in spring or in summer. Carbon disulphide is as injurious to the roots as to the part above ground. Plants should never therefore come in contact with pure carbon disulphide, nor into an atmosphere too highly charged with vapours of this insecticide. According to the experiments of Boiteau the roots may die if they are 4 inches from the spot where the carbon disulphide was injected into the soil. At the dose of 5 c.c. of carbon disulphide per 4 litres of soil, say at the rate of 5 oz. measures of carbon disulphide per 4000 oz. measures ($3\frac{1}{8}$ bushels) of soil, the vine would inevitably die; 2 c.c. of the same product injected into the same quantity of soil (4 litres) might be injurious to a potted plant. The moisture of the soil tones down to a certain extent the injurious action of carbon disulphide; its effect is so much the more injurious to the soil the more dry the soil and the higher the temperature. Just as much as contact with carbon disulphide and its vapours in strong doses are deadly to plants, so also to a like extent are weak doses indifferent to them when they are brought into contact with the roots either in 1 per cent. solution in water, or in the form of vapour. The strong doses applied at the beginning of the phylloxeric invasion always entail the death of the vine, as well as that of its formidable parasite, whilst the cultural doses now used not only do not injure the vine but impart to it exceptional vigour. However, carbon disulphide produces even in a small dose, as Vincey has observed, an injurious action on the plant; but this action is only a passing one and hardly perceptible. In this way vines treated with small doses of carbon disulphide before the unhairing of the buds are thrown back seven to eight days beyond those not treated. Summer treatment always entails a passing slackening in the growth of the plant. Different plants vary in their sensitiveness to this reagent, and it has been observed, for example, that trees generally support larger doses than annual plants. The aerial part of the plant also withstands carbon disulphide up to a certain limit, soapy emulsions and fumigations of carbon disulphide which, according to Morren, are not toxic up to $\frac{1}{1300}$. Goethe has observed that the vine can stand fumigations for twelve hours at 20° C. without suffering. Before the ascent of the sap the vapours of carbon disulphide may be prolonged without injury, and the dose in the same way. Targioni-Tozetti found that the dose of 2 per cent. of carbon disulphide in soapy emulsion was the limit without injury to the leaves, whilst with petrol the dose was 2·5 per cent. A strong dose of carbon disulphide dries the leaves without altering the colour. Seeds likewise undergo the toxic effect of this insecticide, but according to Prillieux their power to withstand it varies with the species. Cereals, for example, lose 50 per cent. of their germinative capacity after eight days of fumigation, whilst beet seeds undergo no alteration after three weeks of this same treatment. Coupin, who examined the action of this agent on grain compared with ether and chloroform, found that these two last bodies had no injurious action on wheat grain when the protoplasm is at rest, whilst carbon disulphide is always injurious thereto. However, if owing to moisture there is swelling and the protoplasm is active, ether also becomes injurious to the grain in the dose of 3·7 c.c. for 10 litres of air (3·7 in 10,000). According to Fantecchi's experiments seed corn dipped two minutes in carbon disulphide and afterwards dried in the air loses 10 per cent.; dipped for one minute only in this insecticide, then exposed afterwards for twenty-four hours in an atmosphere of carbon disulphide, it undergoes a loss of 50 per cent. The grain suffers the same loss if exposed for twenty-four hours in a closed vessel at 30° C. (86° F.); in an atmosphere containing 2 kilogrammes of carbon disulphide per cubic metre if the heat be raised to 40° C. (104° F.) the loss will be 100 per cent.

The most important use for carbon disulphide as an insecticide in the United States is in the fumigation of stored grains, cowpeas, beans, and peas to kill the insects infesting them. Many species of insects are concerned, but all are susceptible to the same treatment. The most important species attacking corn is the so-called black weevil, or rice weevil, *Calandra oryza*, L., which causes a loss amounting to several million dollars annually in each of the South Atlantic and Gulf States. Investigation by the Alabama Experiment Station has shown that the amount of liquid disulphide required for killing grain insects under ordinary conditions of storage is much greater than has been recommended usually, and ranges up to about 20 lb. per 1,000 cubic feet in ordinary rooms where the walls and floor have not been made especially tight (see p. 70).

**Action of Carbon Disulphide on Insects.**—Carbon disulphide is one of the most efficacious of insecticides; it diffuses very rapidly in virtue of its great mobility and its very low boiling-point. Its anæsthetic and asphyxiant properties act very rapidly on the vitality of the insects which die paralysed in breathing it. Insects are generally more sensitive to the action of carbon disulphide than plants, so that by only using doses injurious to insects they can be overcome without hurting the plant. When an atmosphere saturated with the vapour of carbon disulphide can be created around the insects or their larvæ they die in a few seconds. Phylloxera is so killed in thirty seconds. If the atmosphere only contains 0·5 per cent. of carbon disulphide vapours (say 0·0016 of liquid sulphide) the action must last twenty-four hours to kill the phylloxera. An atmosphere containing 0·4 per cent. of $CS_2$ vapour easily kills, in fifteen minutes, grubs, butterflies, grasshoppers, lice, and Coleoptera. Injected into the soil to a depth of 4 inches, doses of 40 grammes per square metre (say $1\frac{1}{3}$ oz. per square yard) for heavy ground and 30 grammes (say 1 oz. per square yard) for dry, light soil, suffices to kill all the insects in that layer of earth. But solutions and emulsions of $CS_2$ do not act so rapidly nor so energetically as the vapour in a closed space. A 1 per cent. solution does not kill the phylloxera until after twenty-four hours' immersion. Grubs strongly resist it. Those of the gypsy moth, *Ocneria dispar*, L., resist soapy emulsions containing up to 10 per cent. $CS_2$. Burleso Dufour came to the same conclusions after trying to kill the cochylis (*Cochylis ambignella*, Hubn.) by emulsions containing 3 per cent. and 10 per cent. of $CS_2$.

The way in which carbon disulphide kills has been studied at the Michigan Experiment Station, where the conclusions have been reached that carbon disulphide vapour very probably acts upon the fatty tissues in the insect body, dissolving them to some extent; that it tends to coagulate the proteins; and that it prevents the assimilation of oxygen and the carrying on of other processes which are of vital importance to insect life. A certain amount of respiration goes on at all times so long as an insect is alive, but it is evident that respiration will be far less in the egg stage or during the dormant periods in an insect's life than it is in the adult stage and during the periods of its greatest activity. The strength of vapour and the time required to kill, therefore, will vary greatly and accordingly. Similarly, slow-moving insects usually are harder to kill than the quick-moving forms.

**Action of $CS_2$ on Fungi.**—This insecticide only acts on fungi in very strong doses, and is only used to kill root rot.

**Influence of $CS_2$ on Fertility of Soil.**—Carbon disulphide, far from injuring the soil into which it is injected, as believed at the outset of its use in vineyards invaded by the phylloxera, exerts even in strong doses a favourable influence thereon. Aimé Girard was the first to observe that carbon disulphide injected into the soil produced salutary effects on the soil treated and greatly improved exhausted soils. In Alsace-Lorraine, where the antiphylloxeric treatment to extinction has so long been used, the marvellous action of carbon disulphide has been remarked by Oberlin. The latter, who has more especially studied the soil cure, has obtained surprising results. The culture of the vine being rigorously forbidden during the next ten years after the extinction treatment, the land was utilized for other crops. Now it was found that in all these soils all species of plants developed in a surprising manner, and that the rotations in use on non-disinfected ground were unnecessary on the former; $CS_2$ regenerates exhausted soils and allows continuous growing of the same crop. All *Papilionaceæ* may be profitably cultivated on lucerne ground; for example, if the soil of the latter is previously tilled and disinfected, whilst in ordinary cropping one plant cannot usually be grown after another of the same nature without intermediate crops; $CS_2$ therefore renders rotations unnecessary, and enables the same plant to be cultivated for several years in succession.

Oberlin, who has greatly helped to popularize carbon disulphide, got, like Girard, a double crop of trefoil after disinfecting the soil, and an appreciably increased yield with grain crops, beets, potatoes, and farm crops generally. In a tares (*Vicia villosa*) experimental field, treated with $CS_2$, Oberlin obtained 45 tons of green fodder per hectare (18 tons per acre), whilst in a non-disinfected field, used as a test, the yield was only 19 tons per hectare (7·6 tons per acre). He also experimented with haricots, and obtained by weight per are 85 kilogrammes in non-treated ground, and 125 kilogrammes in treated ground. Oberlin disinfects the soil as follows: Holes about 12 inches deep are excavated by an iron bar and 25 grammes of $CS_2$ run into each hole and the holes quickly closed; 10 kilogrammes of carbon disulphide must be buried per are. Three weeks after this treatment sow the seeds. Practical experiments on vines gave equally good results. Oberlin first, then Dufour, found that vineyards, before being replanted, have no need, as generally believed, of a rest, nor of any improvement by an intermediate crop after treatment with $CS_2$. The new vine can, in fact, be replanted as soon as the old stocks have been extirpated if the following procedure be adopted: Trench the ground to 65 centimetres (2 feet 2 inches), then at a distance of 50 centimetres (20 inches) apart in every direction dig holes of 50—60 centimetres (20—24 inches) deep. Run into each 100 grammes (say 3½ oz.) say 40 kilogrammes (88 lb.) per acre, and close the holes quickly; the soil must remain in this condition until the spring, when the new plantation will be made. In vineyards reconstructed in that way the young vine stocks yielded in the third year 30 hectolitres (660 gallons); the fourth year, 110 hectolitres (2200 gallons); whilst the test vineyard non-treated only gave 74 hectolitres (1528 gallons). Here is, by a report of the Baden Botanical Station, a curious result obtained in onion-growing. Soils, completely exhausted by the culture of this plant, were appreciably improved by disinfection by carbon disulphide. Holes 40 centimetres deep, bored 50 by 50 centimetres (20 inches) in every direction, received 100—300 grammes of carbon disulphide, and the produce, which had fallen to 14 units per square metre, was raised to 22 by the dose of 400 800 grammes per square metre, and to 26 by a dose of 1000 grammes (2·2 lb.). These improvements, due to carbon disulphide, are very surprising, and efforts have been made to ascertain how this product acts on the soil, since it is void of any nutritive function, and how it can be the cause of intense yields in an exhausted soil?[1] There are a large number of parasites, both insects and fungi, which live in the soil at the expense of the plants, and looking at their grand opportunities for multiplying when the same plant is grown continuously for several years the exhaustion of the soil, it will be readily understood, is due solely to this accumulation of parasites which, attacking the plant by the roots, remove from it the means of nourishing itself. Carbon disulphide, injected into the soil, by destroying all these parasites, restores to the soil its primitive purity, and the plant, undisturbed by parasites, develops normally, and profits, by fertilizers, to give large crops. Carbon disulphide acts like the bare fallow, which also remedies soil exhaustion. By suppressing food for the parasites accumulated in the soil for a certain time the latter greatly disappear. Carbon disulphide is more effective than bare fallow, and gives complete and immediate results, because it enables the soil to be completely disinfected and to utilize it at once for a new crop. The infection of the soil is caused by fungi: *Dematophora necatrix*, Hartig; *Armillaria Mellea*,[1] Quelet; *Roesleria hypogæa*, Thum. et Pass.; by the *Anguillulides, Heterodera Schachtii*,[2] Schm., and *H. radicicola*,[3] Gr., and insects, the larvæ of which take several years to accomplish their evolution, such as the *Elaterides*[4] (click beetles), cockchafers, etc. All these parasites multiply greatly, especially when they are omnivorous and not disturbed by rotations; they are, in themselves alone, capable of preventing a plant from producing normal crops. Carbon disulphide in large doses creates in the soil a sufficiently poisonous atmosphere to kill them, and so sterilize the ground being cropped. It has been shown that carbon disulphide only temporarily affects the bacteria useful to agriculture, and Wollny formulates the results obtained up to now as to the action of carbon disulphide thus:—

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[1] *Note by Translator.*—The onion is a sulphur-loving plant. The reason for increase in crop is obvious.

(1) The introduction of carbon disulphide into arable land during the period of vegetation has the effect, according to the quantity applied, of either completely destroying vegetable life or of causing temporary trouble. (2) When the sulphide is applied several months before cultivating the soil, the fertility of the soil is greatly enhanced. This action of the sulphide extends, according to the quantity used, over one or more periods of vegetation, and it is followed, if manure be not employed, by an important decrease in the yield of the field treated. The lower organisms which play an active *rôle* in the decomposition of organic matter and in the formation of nitrates in the soil, as well as the bacteria of the radicular nodosities of the *Leguminosæ*, are not killed even by strong doses of carbon disulphide; their activity only receives a temporary check, to resume afterwards all its energy.

**Use.**—The method of application and the doses used play, in fact, a *rôle* of very great importance in the services which carbon disulphide might render in destroying the phylloxera of the vine. Monestier, Lautaud, and Ortoman concluded that carbon disulphide is not injurious, except in the liquid state, when it is brought into direct contact with the roots of plants; it is necessary therefore, so as to remedy this drawback, to inject the liquid at a certain distance from the plant in such a way that the vapours disengaged form around the roots an atmosphere sufficiently toxic to kill the parasites. With this end in view they recommended that the carbon disulphide be caused to act from below upwards by depositing this agent in holes pierced to a depth of 80 centimetres (31½ inches); although based on an excellent principle, the use of carbon disulphide too often caused the death of the vine, for the doses used, which varied from 150—375 grammes per stock, were too strong. Experiments by the Montpellier Agricultural Society, due to the initiative of the Viticultural Association of Libourne, led to a gradual decrease in the dose, which was definitely regulated to 12—20 grammes only per square metre, say 24—28 grammes per stock. Dumas' researches showed that even 3 grammes per square metre ($\frac{1}{10}$ oz. per square yard) were sufficient to attain the object in view.

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[1] ARMILLARIA MELLEA (tree-root rot).—This fungus (commonest and most widely distributed of British toad-stools) lives as a saprophyte and as a parasite; its mycelium penetrates into the living roots of very different species of trees and develops in the bark and in the exterior layers of wood; from the roots it gains the foot of the tree and there it produces yellowish-brown clusters of receptacles on the level of the ground. It attacks vines, apple-trees, mulberry-trees, fig-trees, on which it causes diseases which are confused with others under the general name of rot.

[2] HETERODERA SCHACHTII (nematode of the beet).—This microscopic worm is met with on the roots of different plants, such as the cabbage, spinach, colza, but it commits its depredations especially on the beet. The larvæ of the nematodes prick the radicles of the beets with the dart with which they are furnished, and fix themselves by the head in the cellular tissue.

[3] HETERODERA RADICICOLA.—Nematode, which lives as a parasite on the roots of very different plants, but contrary to the nematode of the beet produces galls on the roots. These galls shelter the worm during the whole of its development.

[4] ELATERIDES AGRIOTES.—Wire-worms, click beetles, skipping beetles, skipjacks, spring beetles. Small coleoptera of 1 centimetre at the most elongated and flattened; several species are injurious to grain and other crops. The larvæ alone are injurious. They have a thin, elongated, cylindrical body, like that of a worm; their colour is yellowish, shining; their maximum size is about 2 centimetres ($\frac{3}{4}$ inch) long; their skin is scaly, very hard, and difficult to crush. Their development is very long; it lasts five years.

At the present time the utility of carbon disulphide is no longer in doubt; it has rendered, and renders, undoubted services, and its use has become universal. Its method of use varies according to the parasite to be destroyed. The best results are got when an atmosphere containing a dose poisonous to insects and their larvæ can be produced. This condition is easily realized underground, in granaries, hothouses, and under tents of impermeable cloth, with which small-sized trees may be covered. In these different cases liquid carbon disulphide is always used, and acts by evaporation. When an asphyxiating atmosphere has to be produced underground, the carbon disulphide is introduced to a certain depth by a soil injector, which is regulated for the desired dose. In soils favourable to the diffusion of gases, such as those which are not too compact nor too moist, the vapours of carbon disulphide, in a dose of 20 grammes (307 grains) spread within a radius of 30—35 centimetres (10—12 inches) around the spot where it has been poured. These vapours remain long enough in the soil for the toxic atmosphere to produce its effect. According to the parasites to be got rid of the dose is diminished or increased, and injected to a variable depth. There are cases where the roots of the vine descend so deeply that the carbon disulphide must be injected to 80 centimetres (31½ inches), whilst to kill the larvæ living a few centimetres from the surface, one does not go down more than 20 centimetres (7·8 inches). To use carbon disulphide it is therefore necessary (1) To ascertain the exact spot where the parasites to be killed are, first making a trench and making it at about 20 centimetres (7·8 inches) below the invaded zone. (2) To choose the moment when the soil is in such condition as to allow the diffusion of carbon disulphide vapours into the interior of the mass, whilst at the same time it places the greatest possible obstacles in the way of their loss. This moment varies with the nature of the soil to be treated. A clay soil, for instance, cannot realize favourable conditions when it is saturated with water, or when it is cracked by drought. On the contrary, a sandy soil, after a slight rain, is in favourable condition. The most propitious moment is when the soil presents a certain interior mobility and a great enough density on the surface. In these conditions the vapour of carbon disulphide easily diffuses around the roots, and remains imprisoned by the hard surface, which forms a sort of envelope. Those advantageous conditions may be realized artificially by injecting carbon disulphide into a very dry soil and watering the surface soil, after having carefully plugged the holes. (3) Never to stir the soil after treatment, for the carbon disulphide, already very volatile, would, in certain instances, escape into the air without producing its effect; it is therefore necessary, so as to employ it with success, to maintain it as long as possible in the infected zone. To attain this end recourse has been had to two preparations, which allow a less rapid evaporation of carbon disulphide.

**Vaselinated Sulphide.**—In 1874 Bouttin proposed a mixture of carbon disulphide and nut oil. Cubes of wood, soaked with sulphide and covered with silicate of soda have been tried but neither of these processes have given good results. Vaselinated sulphide was invented by Dr. A. Meunier and examined by Cazeneuve: vaseline (petroleum jelly, known by this trade name) forms an emulsion with carbon disulphide and prevents it from evaporating rapidly. It was hoped, owing thereto, to lessen the chances of evaporation into the atmosphere and to prolong its action in the soil. Mixtures were tried of equal parts of the two substances, or of 30 per cent. of vaseline and 70 per cent. of carbon disulphide. It has been observed by Vermorel and Jossinet that the dose of 20 grammes of liquid carbon disulphide placed in each hole 35—40 centimetres round the vine suffices to kill the phylloxera, but when mixed with vaseline this quantity is not enough. However, if the holes be brought to within 10—15 centimetres of the stock, the conditions favourable to the action of this preparation are improved. Marion and Gastine conclude that there is no advantage in this mixture, since the dose of sulphide must be greater to give the same result. They further remark: If more than 50 per cent. of vaseline be incorporated in the carbon disulphide, the evaporation which is produced during injection is as great as when employed pure, and finally the vaseline retains about 15 per cent. of sulphide which it only cedes very slowly, and which remains without effect. Wooden cubes impregnated with sulphide as well as mixtures of carbon disulphide and heavy oils, gave no advantageous results, and the pure sulphide should be preferred to all these preparations. It is a great error to imagine that carbon disulphide must develop slowly to produce a salutary effect. For the action of the sulphide to be effective, what is required, above all, is to create almost instantaneously an atmosphere highly charged with poisonous vapours around the radicular system invaded by the parasites and to maintain it there as long as possible. To slacken the evaporation of the carbon disulphide is to remove from it one of its precious properties, that of its great diffusibility. A slower evaporation will not create an atmosphere sufficiently toxic to kill the parasites. A great number of volatile substances, very poisonous to the phylloxera and used in the same conditions as carbon disulphide, have never been able to equal it, as their diffusion in the soil was too slow. To avoid the loss of carbon disulphide in the usual treatment with the injector, the use of gelatinized capsules containing a dose has been tried. These capsules are arranged in holes made with a soil-injector, and afterwards plugged. Under the action of the moisture of the soil the gelatine finally dissolves, the sulphide flows out into the soil and rapidly evaporates. The operator has thus a convenient time without fearing loss of the sulphide to plug the holes and to water the surface of the soil to imprison the vapour after the rupture of the capsules. In spite of the apparent advantages of this process, it has had to be renounced in viticulture because the disengagement of sulphide was too irregular and not simultaneous in the zone treated. In horticulture these capsules are handy because they are easy to use and as they avoid the purchase of a soil injector. (4) To distribute uniformly the sulphide in all the soil to be treated. This is done by placing the holes at equal distances from each other, and by using instruments which enable equal doses of this substance to penetrate into the soil. Carbon disulphide may be injected into the soil during almost the whole year. However, it is less injurious to the plant if the operation be performed during the time vegetation is at rest. In any case, its use should be avoided during the flowering period and when the fruit approaches maturity.

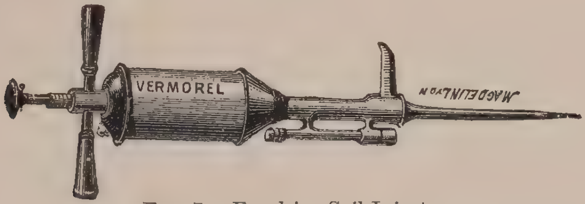

FIG. 7.—Excelsior Soil-Injector

**Instruments Necessary for applying Carbon Disulphide.**—The injector already mentioned must be placed in the first rank of instruments intended for this purpose. It is a sort of compression pump, intended to convey a known dose of carbon disulphide to a certain depth. The earlier type consisted of a reservoir in zinc or copper, intended to contain carbon disulphide. This instrument possessed, in its interior, the body of a pump in which a piston moves. Under the pressure of the latter a valve opened and closed the opening of a long channelled tube, which penetrates into the earth. An aperture near the sharp end lets the sulphide escape. In hard and gravelly soils the workman was preceded by an assistant, who pierced the holes with an iron crowbar. Vermorel later invented the *pal-Excelsior*, which differs from the foregoing by the fact that the valve is placed in a lateral tube by which it is possible to have a much stronger perforating tube. To regulate the quantity of carbon disulphide it suffices to give a longer or shorter course to the piston, by intercalating washers in the body of the pump. By this means the *pal-Excelsior* can be regulated at will for an output of 5, 6, 7, 8, 9, and 10 grammes of carbon disulphide at each injection. In actual sulphurization the injector is seized by the two handles, then sunk in the ground by the help of the pedal. By pressing on the rod of the piston the carbon disulphide is projected into the soil, then the rod re-ascends of its own accord, under the action of an inside spring. The injector is withdrawn from the soil, and an assistant rapidly fills up the hole with a wooden rod ending in a rounded piece of iron or lead. To hasten the operation, which ought to be done very rapidly, it is well to employ three workmen, and to possess two injectors. A workman fills the container of the injector by a tap fixed on the barrel, whilst the second injects, and the third plugs the holes. In vineyards arranged for the work the injector is replaced by sulphide wagons or traction injectors, which do the work much more rapidly, and thus economize manual labour. The mechanism of these machines comprises a roll, acting like a pump, which after drawing the carbon disulphide into a reservoir, spreads it into a hollow traced by the sock of a plough, which immediately covers the hollow which has just been excavated.

In other appliances the organs of distribution of the carbon disulphide are fixed to some sort of plough. These machines are criticized for not depositing the sulphide deep enough in the soil. To secure a good distribution of the carbon disulphide through the layer to be disinfected, recourse is often had to 1 per cent. aqueous solutions. At that strength the carbon disulphide is not injurious to the plant, but perfectly capable of killing subterrannean parasites.

**Disinfection in Closed Spaces.**—$CS_2$ is used in granaries where food-stuffs are stored. It suffices in that case to spread on the floor a certain dose of carbon disulphide, after having closed all the vents in the place. A toxic atmosphere must contain 0·5 per cent. of carbon disulphide. When it is required to disinfect a small quantity of corn, it suffices to enclose the grain in a cask containing 0·5 per cent. of sulphide, and to keep the cask hermetically closed for twenty-four hours. The grain sometimes acquires a bitter taste after this treatment, but this is removed by stirring the grain with a shovel, or by passing it through the fanners. What is important to be pointed out is, that the grain suffers no alteration and retains its germinative and alimentary faculties. Carbon disulphide therefore presents real advantages over sulphurous acid employed in like conditions, the latter having the drawback, according to Balland, of removing from the gluten the special qualities which enable it to be used in bread-making (see p. 63).

**Destruction of Aerial Parasites.**—When the plant attacked is of no great height it is covered with a tent of impermeable oil-cloth, or by a zinc bell, or better still, by half a barrel (petroleum), as is done in the treatment of vines by sulphurous acid. By this means an atmosphere containing vapours of carbon disulphide can be created around the tree, capable of rapidly destroying the parasites without injuring the plant, whilst, according to Ritter and Moritz, the phylloxera under its *gallicole* form and its winter egg, is killed in half an hour at a temperature of 20—30° C. (68—86° F.) in an atmosphere containing a sufficient dose of sulphide. The vine supports without suffering the action of this gas for twelve hours at 20° C. (68° F.). It is, however, to be observed that the longer the duration of the treatment, and the higher the temperature, the greater is the action of the sulphide on the plant. The dose of sulphide to use ought never to be greater than 0·5 to 1 per cent. For this purpose 50—100 grammes of sulphide per cubic metre are placed in a cloche or in a flask hooked to a branch, or on the soil in a saucer. In hothouses the atmosphere must not contain more than 0·5 per cent. of carbon disulphide. To destroy the larvæ of xylophages, such as the larvæ of the Saperdes, the grubs of Cossus,[1] and of Sesia, a poisonous atmosphere is formed in the burrows they make in the trunks of trees. To imprison the vapours it is necessary to close the burrows with some sort of mastic. This treatment is in no way prejudicial to the plant. Where fumigation in an enclosed space is impracticable, recourse is had to pulverizations with soapy emulsions, made in the same way as those with a petroleum basis, and containing 2 per cent. of sulphide, the limit of innocuity on the tender parts of the plant. In certain cases the invaded spots are plastered with the pure sulphide by means of the brush, and that chiefly when it is a case of the destruction of the woolly aphis (*Schizoneura lanigera*). The action of the sulphide employed in this way is not so perfect as in a hothouse, or under a cloche, its rapid evaporation not allowing of a sufficiently long action which thus often allows the parasite to escape death.

**Use against Cryptogamic Diseases.**—*Dematophora necatrix*, Hartig.—Jean Dufour, Director of the Station Viticole de Lausanne, succeeded in arresting *Rhizoctinia* of the vine by applying carbon disulphide at the rate of 200 grammes per square metre (say about 7 oz. per 40 inches square), after having removed the diseased roots. According to this eminent observer carbon disulphide not only acts by destroying the mycelium of the fungus in a great measure, but it also imparts greater vitality to the vine. The latter, rendered more vigorous, resists afterwards the action of the fungus which may have escaped the destructive treatment. Oberlin and Foëx believed that the improvement in soils got by the use of the exterminating treatment against phylloxera is due chiefly to the destruction of the mycelium of injurious fungi which intervening crops are not capable of eliminating, because they can live, if need be, just as well as saprophytes as parasites on different plants. To disinfect a vineyard it is advisable to proceed as follows: After having staked out the ground by metric divisions, two holes per metre 25—30 centimetres (10—12 inches) in depth are made with an injector and 100 grammes (3½ oz.) of carbon disulphide are injected into each. In compact soils four holes are made, each of which receives 50 grammes of sulphide. It is always well to water the ground after this operation, so as to maintain the carbon disulphide as long as possible in the soil. This treatment is generally carried out in winter, and the vines are replanted the following spring. Carbon disulphide is not applied against any other cryptogamic diseases, but it possesses, however, a certain action on the spores of fungi. Dr. Delacroix in his researches on the *Fusarium Dianthi* (P. et D.) observed that the conidia are killed after seven hours in an atmosphere saturated with carbon disulphide, and that the chlamydospores are destroyed after twelve hours. The spores of fungi resist the action of carbon disulphide much better than insects, but it is not impossible that the sulphide will yet find some applications for the destruction of certain fungi refractory to the action of the different cryptogamic bouillies.

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[1] COSSUS LIGNIPERDA (goat moth).—This bombyx lives three to five years as a grub which attacks indifferently weeping willows, poplars, elms, fruit trees, larches, and many other trees; it bores holes into these trees of the thickness of a finger which in multiplying form immense cavities on the trunk. The caterpillar is bright red in colour; it gives off a decided odour of musk.

**Use against Anguillulideæ** (Eelworms). — *Heterodera Schachtii* (nematode of beetroot).—Kuhn, who has principally studied this parasite, believes that the exhaustion of the soil in beet cultivation is not due, as is generally imagined, to the want of potash or other elements necessary to intensive cultivation, but exclusively to the exaggerated development of this eel. Rotations are powerless to destroy this parasite, because it lives quite as well on other plants. Carbon disulphide was not recommended until 1877 by Aimé Girard, after he had discovered its surprising effects. In Germany, Hollrung also got good results by the use of this insecticide, provided it was used in a large dose, that is to say, of 1·8 metric tons per hectare (say 1584 lb. per acre) spread in holes placed regularly 50 centimetres (20 inches) apart.

*Heterodera radicicola*, Greff. (root eelworm).—Dussuc recommends for the destruction of this eelworm the cultural treatment used against the phylloxera. The different nematoides that live on the roots of all these plants of large scale agriculture, and which neither deep cultivation nor rotations can destroy, contribute in great measure to create that peculiar state of soil known as *exhaustion*. In these conditions when their presence in very great number is recognized in a soil, it is well to have recourse to a complete disinfection of the soil, using heavy doses of carbon disulphide. This treatment will maintain the fields in good condition for several years, especially if care be taken not to convey thereon farmyard manure liable to contain eelworms.

**Use against Insects.**—Insects the larvæ of which live at the expense of the roots may be destroyed by carbon disulphide used in the conditions indicated to destroy the phylloxera.

*Melolontha vulgaris* (cockchafer).—In carbon disulphide an infallible remedy has been found for the destruction of the larvæ of the cockchafer, the white worm, on condition that it be applied at the right time and intelligently. Falconnet and Treyre, who were the first to use this insecticide as far back as 1883, pointed out the absolute efficiency of this treatment. (U.S. investigators state that, though the fumes of carbon disulphide have a marked effect on *Melolontha*, provided that the concentration and time of exposure are sufficient, hydrocyanic acid gas and chloropicrin are more rapid and complete in their action.) There do not exist for this particular application of carbon disulphide precise data as to the depth to which the injection should be made. The white worm travels, in fact, constantly in the soil; it rises and descends according to the hygrometric condition of the soil, and the temperature. In winter it buries itself at a depth where it cannot be reached by insecticides, in summer it ascends, on the contrary, into the superficial layers where disinfection cannot reach it, the tension of the vapour of carbon disulphide not being sufficient, and the larvæ often finding enough air to escape asphyxia. It is therefore necessary to seize the moment when the larvæ are about 30—40 centimetres (12—16 inches) from the surface of the soil, that is to say, about the month of October or November, when it descends, or in the month of

February, when it re-ascends into the surface layer to commence its ravages. So that the treatment may be followed by a complete result, it is necessary that carbon disulphide invade the whole zone of soil occupied by this dangerous larva; the treatment ought, therefore, to be preceded by trenching with the spade which should determine for the moment the spot occupied by the white worm. The injection is regulated in such a way that carbon disulphide is volatilized appreciably in that zone, which will be reached by working 5 centimetres further down. It is useless to treat the soil during the period of the year the perfect insects appear, and which current language designs as beetle seasons, the laying being done in the month of June, the white worms, which are hatched a short time afterwards, do not yet cause appreciable damage, and moreover these young larvæ reside so near the surface soil that it would be difficult to attack them. The treatment is put off generally until the month of February of the second year, and the time chosen the moment the larvæ appear on the surface of the soil. The laying of the beetle occurring only once in three years, there is only one favourable period occurring in this interval. It only lasts a few months. It can be applied in market garden or in nurseries without entailing great expense. It has the advantage of killing at the same time rats, mice, moles, mole crickets, grey worms, and all the parasites which injure crops. Falconnet and Treyre have found that the dose of 10 grammes per square metre (154 grains per 40 inches square) is sufficient in orchards to kill the larvæ in the deep layers of the soil. Vermorel and Couanon recommend a stronger dose, that is to say, 20—28 grammes per square metre ($\frac{3}{4}$ to 1 oz. per 40 inches square). To spread this insecticide use is made of a soil-injector, which is regulated to distribute 5 grammes (77 grains) at a time in holes placed 50 centimetres (20 inches) apart in every direction. But the number of holes and the dose vary according to the nature of the soil and the kind of crop. On nurseries planted with grafts, the maximum dose is 200 kilogrammes, say 4 cwt. per hectare (176 lb. per acre); in these the tool ought to be sunk 35 centimetres (say 14 inches) in the soil, so as to inject the carbon disulphide lower than the roots, and thus to avoid contact with the liquid sulphide. On a soil free from any crop the best moment to treat it is likewise in the middle of the month of February, and in general it may be said that injections ought always to be made fifteen days before planting, provided the soil is very dry. If carbon disulphide has to be employed in the months of May and June, whilst the white worm exercises its ravages in the upper layer of the soil, Vaucher advises to spread a dose of 50 grammes per square metre, in six to eight holes of 18—20 centimetres (7—8 inches) deep. Gelatine capsules containing $2\frac{1}{2}$ grammes of sulphide render good service under these conditions. It is necessary carefully to avoid working the soil fifteen days at least both before and after the treatment.

*Eumolpus vitis*,[1] F. (Ecrivain).—Besides the very efficacious method which consists in shaking the branches above a special funnel, carbon disulphide, applied as in the case of the phylloxera, is capable of giving good results. It is applied at the rate of 200 kilogrammes per hectare. This treatment has succeeded perfectly in Hungary.

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[1] Eumolpus vitis, F. (*Adoxus vitis*).—Chrysomelide 5 millimetres in length, elytron (wing shell), maroon red, corselet and head, black. The larvæ hatch about mid-June and pass the winter following in the subsoil where they feed on the vine roots. In spring they turn into grubs. The perfect insect hatches in the month of April or May. It first attacks the leaves, drawing straight and angular furrows; then the grapes, on which it makes grooves, which hinders the development of the grape and prevents it from ripening.

*Vesperus Xatarti.*[1]—Olivier recommends destroying these insects by treatment with carbon disulphide, applied in the months of December and January. For that purpose, two or three holes are made 25 centimetres (10 inches) from each stock, and into each hole 7 grammes (¼ oz.) of carbon disulphide is poured.

*Euchlora vitis*[2] (green vine beetle).—Marchal recommends carbon disulphide as very efficacious in destroying the larva of this beetle.

*Pentodon punctatus*[3] (Pentodon ponctué).—Dussuc advises destroying the larva of this Coleoptera by carbon disulphide, and previously to disinfect soils intended to receive grafted plants where this insect is very abundant.

*Lethrus cephalotus*,[4] Fb. (big-headed lethrus).—Carbon disulphide, it appears, gives good results in the destruction of this Coleoptera; however, it is advisable to make weak injections, for these must be done very near the stock, the insect being always found hidden in the neighbourhood of the roots.

*Oryctes nasicornis*,[5] L. (rhinoceros).—Carbon disulphide gets rid of them.

*Melolontha Fullo* (fuller beetle); *Rhizotrogus solstitialis* (St. John beetle).—To destroy these insects in infested regions the sulphide should be applied before planting.

*Larvæ of the Elaterides* (wire worm).—A great number may be destroyed in infested fields by laying down small pieces of apple as bait, which as soon as invaded are collected (see note, p. 8). But complete destruction is only possible with carbon disulphide, which, in the different tests made, has always given good results. T. Tozetti has used the sulphide with a dose of 300—400 kilogrammes per hectare (264—352 lb. per acre), or even at a dose of 100 kilogrammes per hectare (88 lb. per acre) in emulsion with 100 kilogrammes of 4 per cent. caustic potash and 15 kilogrammes (13·2 lb. per acre) fish oil. The result is not perfect, except after having renewed the treatment, the success of the first injections only being momentary.

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[1] Vesperus Xatarti.—Greyish longicorn coleoptera, 2 centimetres in length. The female of this Coleoptera lays 200—500 eggs in the beginning of winter under the bark of vine stocks. This insect is spread chiefly over the north of Spain, and in France, in the departments of the Pyrénées-Orientales and Aude.

[2] Euchlora vitis (*Anomala vitis*, green cockchafer of the vine).—The female of this Coleoptera lays about thirty eggs in the soil round the stem; the larvæ appear in the beginning of the month of August.

[3] Pentodon punctatus.—This Coleoptera, injurious to vines, much resembles the bousier. Its larva, which when full grown is twice the size of the white-worm, lives in the soil to the detriment of the new plantations of grafted American vines, for which it has a marked preference, of which it gnaws the young wood for two to three years.

[4] Lethrus cephalotus (big-headed lethrus).—The lethrus is injurious to vines. It is 2 centimetres long, its body is globular and black. The lethrus is chiefly met with in Russia and Austria-Hungary.

[5] Oryctes nasicornis. *Rhinoceros.*—The larva of this large insect resembles an enormous white-worm. Generally it lives almost exclusively on decomposing vegetable matter, in melon beds, and in dung in gardens.

Brocchi, as well as Mohr, has obtained excellent results against *Agriotes sputator* by using capsules containing carbon disulphide. The larvæ of the *Elaterides* are very hardy, and as they live mostly in the upper layers it is advisable to make holes 20 centimetres (7·8 inches deep) and run in a dose of 50 grammes of sulphide per metre, say 775 grains per 140 inches square. It would be advisable to roll the ground before treatment to consolidate it and prevent the sulphide from evaporating too rapidly. Amongst the weevils there are several which can be destroyed by carbon disulphide.

*Peritelus griseus* [1]; *Othiorhynchus sulcatus*, Fb. (black vine weevil).—Muller advises to make three or four holes per square metre round the tree and to distribute therein by the injector a total dose of 25 grammes of carbon disulphide. Insects hidden underground should be exterminated at the end of May, and the larvæ during summer.

*Othiorhynchus ligustici*, L. (Liveche's weevil).—Treatment with carbon disulphide is most efficacious. *O. raucus*, Fb., and *O. picipes*, Fb. (clay-coloured weevil), both injurious to fruit trees and vines, may be treated in the same way.

*Bruchus Pisi*,[2] L. (pea-beetle).—This weevil passes its entire evolution on the pea. Peas intended for sowing should be disinfected. Reh has observed that the treatment by carbon disulphide was in this case as efficacious as hot water. It suffices to treat peas for twenty-four hours in a closed vessel and to aerate them afterwards. This same process is applied to *Bruchus rufimans*, Schonh. (haricot-weevil); to *Bruchus granarius*, Payk (bean-beetle); *Calandra* [3] *granaria*, L. (calender or wheat-weevil); *Calandra oryzæ*, L. (rice calender), and *Anobium paniceum* (maize-weevil). The larvæ of these weevils live inside the grain and cause great ravages in granaries. The following processes have been used to exterminate them. Spread on the floor of the infected granary 1 litre of carbon disulphide (35·2 fl. oz.), pile the grain in a heap on the drenched space, and cover it with a tent or a cloth. The grain may also be spread in a closed chamber, in a layer 20—30 centimetres deep and 1—2 litres of sulphide per ton of grain to be disinfected uniformly distributed thereon. The whole is covered with sacks, and the sulphide allowed to act for twenty-four to thirty-six hours. This method of disinfection has the drawback of being attended by certain fire risks, and that is why it is done far from dwellings. In that case a cask is used, which is filled with grain, then the carbon disulphide is run in at the rate of 500 grammes (1·1 lb.) per 100 kilogrammes (220 lb. of wheat). The cask must be closed, with its lid, so as to roll it, first, shortly after closing and then a second time, twelve to twenty-four hours afterwards. Nothing remains to be done but to empty the grain, which is perfectly disinfected (Pabst and Hollrung). The resultant bad taste does not last long, and it rapidly disappears if the grain is shovelled a few times, or passed through the fanners.

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[1] PERITELUS GRISEUS.—This little weevil nightly attacks in hundreds the buds of the vine and fruit trees. It preferably hides during the day in the buds or in the soil at the foot of the vine.

[2] BRUCHUS.—Small, squat-shaped weevils which attack the different leguminous seeds, peas, lentils, beans, tares, haricots. Each of these is attacked by a special species of *Bruchus*, but always in the same way. The perfect insect lays its eggs in the spring in the pods as they are being formed. The larvæ penetrate into the seed; there is generally only one larva per seed except in beans and haricots, where there may be two. The seed develops in the usual way, for the larva gnaws the albumen whilst respecting the grain. The seeds attacked are easily known by their light weight, for they float in water, or by the small opening through which the insect has made its exit.

[3] CALANDRA GRANARIA (wheat weevil).—Black Coleoptera 3—4 millimetres long, the head is prolonged by a lengthy rostrum. The calandra passes the winter in the depressions of the floor; in the spring it gets into the heap of wheat, pierces a small hole in the groove of the grain and there lays a single egg. The same weevil pierces a large number of grains until it has ceased laying.

*Hypera polygoni.*—The larva of this weevil attaches itself to the stem of the poppy and forms a disease of that plant. Sorauer advises the application to the stems of a soap emulsion, containing a little carbon disulphide.

*Saperda carcharias,*[1] L. (large poplar longicorn).—It is recommended to inject carbon disulphide into the burrows occupied by the larvæ and to stop the holes at the base of the trunk with mastic. The larvæ of *Lucanus cervus* [2] (stag-beetle) in old oaks are destroyed in the same way, as well as numerous capricorns, of which the following are the principal :—

*Cerambyx heros,*[3] F. (great capricorn injurious to oaks); *Cerambyx dilatatus*, Ratzeb. (maple capricorn); *Galeruca calmariensis* (elm galeruca).—The larvæ pass through their first stage of metamorphosis underground, in the neighbourhood of the trees, in the end of July, and the perfect insects pass the winter in the same spot. It is therefore at these two periods that it is possible to destroy them by injecting into the soil 50 grammes of carbon disulphide per square metre, spread all round the stock, in eight holes only 20 centimetres (7·8 inches) deep. Watering of the soil before the application facilitates the action of the sulphide on these insects lodged in the upper part of the soil. Carbon disulphide has also been employed with equal success against :—

*Gryllotalpa vulgaris* (Courtilière, Taupe, Grillon), (mole-cricket, churr-worm, eve churr, or earth crab).—Soils are rendered immune for ten years by carbon disulphide on condition, however, that there is co-operation between the different proprietors of the neighbouring cultivated fields. The sulphide is employed at the rate of 40 grammes per square metre if the soil is compact, and at the rate of 30 grammes only when the soil is light. The latter type of soil is always preferred by the insect. In Italy, near Nola, where mole-crickets have caused serious ravages for twenty years, carbon disulphide has been used over a great area, and has been recognized as an infallible insecticide. Janin advises gardeners to use capsules containing 3 grammes of sulphide, and to deposit them here and there in their burrows, and afterwards to water the soil. It is preferable to make injections in the burrows, by making numerous holes, in the spring.

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[1] SAPERDA CARCHARIAS (shagreen saperda).—Among the longicorn Coleoptera injurious to wood, the saperda is one of the most common. It is 27 millimetres in length, brownish-yellow colour; the elytra carry black projecting points which impart to them a shagreen appearance. The larva of the saperda is one of the most dangerous to young poplar plantations. The trunks of certain poplars, less than twenty years old, are sometimes riddled with holes to such a pitch, that a slight gale suffices to cause them to fall. SAPERDA POPULNEA (saperda of the poplar).—This saperda is only 10—12 millimetres in length; it is blackish-brown; the elytra are spotted with small yellow dots. The female lays its eggs in the branches of the poplar. The larva penetrates into the branch, and there bores a long hole.

[2] LUCANUS CERVUS (stag-beetle).—Large Coleoptera, 3—4 centimetres long, furnished with very highly developed deer-horn-shaped mandibles. The larvæ, the development of which takes four to five years, bore holes in the trunks of the oak, birch, and beech.

[3] CERAMBYX HEROS (the great capricorn).—Black Coleoptera 5 centimetres long with two long antennæ which in the male are longer in the body. The larvæ which are very large attack the oak preferably; they take three years to become perfect insects and cause the death of the finest trees by the numerous and wide burrows which they bore in the trunk.

*Tipula oleracea* [1] (daddy longlegs), *Tipula pratensis* (the spotted garden gnat).—Marechal got good results by injecting carbon disulphide. To free a lawn from the larvæ of these insects 20 grammes of carbon disulphide should be spread in three holes per square metre, the grass trenched after a few days and sown with the seed. There may be destroyed in the same way the *Tipula crocata* and the *Tipula melanocera*, injurious to young plantations of *Abies balsamea* and of *Pinus sylvestris*.

*Spilographa cerasi*,[2] F. (cherry spilograph, cherry fly).—Besides the process which consists in collecting all the wormy cherries, Taschenberg recommends as an excellent means of destruction, to bore numerous holes, in the month of July, of 10 centimetres (4 inches) in depth, around the cherry trees and to run in a little carbon disulphide, to stop them afterwards, and water the soil. The soil under the tree may also be watered with a solution containing 1 part in 1000 of carbon disulphide.

*Vespa vulgaris* (common wasp), *Vespa crabo*.—To destroy these hymenoptera 20 grammes, say $\frac{3}{4}$ oz. by weight, of carbon disulphide is run into their nest during the night, and the orifice plugged.

*Agrotis segetum*, W. V. (common dart moth).—The grub of this moth is known as the grey worm. Coste-Floret has observed that the French vine, which regularly undergoes antiphylloxeric treatment, does not suffer from grey worm, whilst American vines, which are not treated with carbon disulphide, suffer much. The grubs of the following insects may also be combated by carbon disulphide, using the same process:—

*Agrotis exclamationis* [3] (heart and dart moth), *Agrotis Tritici*,[4] *Agrotis Ravida*, W. V., *Agrotis nigricans*, L., and *Agrotis corticea*, all injurious to crops. *Agrotis vestigialis*, Hfu., injurious to pines and larches. *Hespialis Humuli*, L. (the otter moth), the larvæ of which gnaws the large roots of the hop from the month of August to the month of April.

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[1] TIPULA OLERACEA (meadow tipula). TIPULA PRATENSIS (garden tipula).—The tipulæ resemble large gnats with long legs; the body is grey, highly elongated. These large mosquitos lay their eggs in June in the soil. The larvæ (large grey grubs, known as leather jackets), which hatch in eight days, live underground, where they attack the radicles of kitchen garden plants and ornamental plants.

[2] SPILOGRAPHA CERASI (cherry-fly). -This fly, 4 millimetres long, is brilliant black with a head and legs yellow and the wings crossed by four black bands; it appears at the end of May. The female lays a single egg on each cherry, preferably on the *bigarreau* and the geans.

[3] AGROTIS EXCLAMATIONIS or NOCTUA EXCLAMATIONIS.—The heart and dart moth. Dark lilac caterpillar, three bright longitudinal lines. The caterpillar gnaws the neck of roots and kitchen garden plants, turnips, asparagus; in spring it is particularly injurious to vines, the buds of which it gnaws.

[4] AGROTIS TRITICI. *Noctua of Wheat*.—See AGROTIS SEGETUM (p. 26).—Similar caterpillar also called *grey-worm*.

*Cossus ligniperda*, L. (goat moth).—Taschenberg recommends to make injections of carbon disulphide in the burrows as soon as the grub appears, and to close the orifices with mastic; the grub is asphyxiated without injuring the tree. Trees attacked interiorly by the grub of the following butterflies may be treated similarly :—

*Zeuzera Æsculi* (leopard moth of chestnut), *Sesia apiformis*, L., Hornet (wood leopard moth).

*Phthorimœa operculella*, Zell. All stages of the potato tuber moth can be killed in mature potatoes by fumigation with carbon disulphide at the rate of 2½ lb. per 100 cu. ft. injected at a 27 in. mercury vacuum. This treatment cannot be applied to new, immature potatoes, as the fumigation causes scorching.

Amongst the *Microlepidoptera* which may be combated by carbon disulphide, those injurious to stored grain may be quoted, such as :—

*Sitotraga Cereallela*, A. (grain alucite); *Tinea granella* (grain mite); *Asopia farinalis* (flour mite).—They are destroyed like the wheat weevil.

*Cemiostoma scitella*,[1] Zell.—Sirodot recommends to combat this grub and exterminate the butterfly to hook on to the tree a flask containing carbon disulphide. All the Lepidoptera, of which the larvæ are minute, may be destroyed in the same way, such as *Elachista*, *Nepticula*, *Incurvaria*, *Coleophora*, *Cosmopterix*, *Gracilaria*, etc.

*Plant Lice.*—According to a report of the Minister of Agriculture of the United States, all root lice, of which the phylloxera is the best known, may be destroyed by carbon disulphide injected into the soil, around the infected plant. Amongst these lice, which live on roots, the following are the most important: *Phylloxera*, Fonsc.; *Schizoneura*, Hart.; *Pemphigus*, Hart.; *Tychea*, Koch.; *Trama*, Heyd.; *Rhizobius*, Burm. These lice, which, for the most part, do not live exclusively on the roots, become especially injurious because they wither the latter up by their perpetual suction, and so kill the tree.

*Phylloxera vastatrix* (phylloxera of the vine).—To destroy the phylloxera, either aerial or underground disinfection is used. The aerial disinfection of the winter egg of the phylloxera, under the form of "gallicole," is done by methods described further on. However, it may be carried out by means of carbon disulphide on grafts and buds from a contaminated region, because a sojourn of an hour in an atmosphere saturated with the vapour of this insecticide is sufficient to kill the phylloxera and its eggs. Buds and plants may be so disinfected.

**Underground Disinfection.**—This method of disinfection is the most important. It is, in fact, because it withers the roots of the vine that the phylloxera kills this plant and destroys entire vineyards. Amongst the numerous insecticides, proposed for the destruction of the phylloxera, carbon disulphide, and its derivatives, the sulphocarbonates, have alone given good results. According to the district, and also as circumstances may require, two distinct treatments may be applied :—

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[1] CEMIOSTOMA SCITELLA (black spots of the leaf of the pear).—Microlepidoptera, the caterpillar of which is minute, which is to say that it gnaws burrows between the two epidermes of the leaves of the pear. These spots become black.

1. The extermination process, destroying all the insects of the vine and the plant itself.

2. The cropping process, only destroying a portion of the insects, and not injuring the vine, so that the latter, in spite of its parasites, may produce sufficient crops.

**Extermination Treatment.**—In districts far from invaded centres, where an invasion of the phylloxera is in its initial stage and shows itself in certain isolated spots, which threaten a whole vineyard, there must be no hesitation at the right moment to adopt the extermination treatment, which is capable of radically arresting the propagation of the insect, but it is necessary to sacrifice, at the same time, the attacked vines. This process, which is less and less used, since by the cropping treatment the plant may be maintained in a passable state of resistance, was in use, and even obligatory, in the borders of France, Switzerland, and Alsace-Lorraine, the vineyards of which, constantly threatened by destruction, were only preserved by these drastic measures. The extermination treatment is as follows: As soon as the phylloxera makes its appearance in a vineyard, the vine stems are cut down level with the ground, over the whole surface infected; these stems are burned on the spot. Before pulling up the stocks, holes 60 centimetres (24 inches) deep, 50 centimetres (20 inches) apart, in all directions, are made in the soil, and 50—100 cubic centimetres ($1\frac{3}{4}$—$3\frac{1}{2}$ fl. oz.) of carbon disulphide poured into each hole, which is plugged. If the soil be dry it is slightly watered, so that there forms on the surface a slight crust, which prevents the too rapid evaporation of the insecticide into the air. Three years after this disinfection all the stocks with their roots are pulled up and burned on the spot, after drenching them with tar. Fifteen days afterwards two new applications are made with weaker doses; 50 cubic centimetres per hole then suffice. In Alsace-Lorraine, where this treatment was prescribed, it was forbidden to replant the vine for ten years. Since the researches of Oberlin and Dufour have cleared the minds of the authorities, the vine can be replanted the spring following the treatment. These vines are, moreover, of extraordinary vigour, and yield from the fourth year a better crop than that obtained in untreated vineyards. If the extinction treatment was capable of retarding the phylloxeric invasion for several years, it has never, on the other hand, prevented subsequent invasions, so that this very costly treatment has been abandoned.

**Cropping Treatment.**—Instead of destroying the vine by heavy doses of $2\frac{1}{2}$ tons to 3 tons of carbon disulphide per hectare (1 ton to 24 cwt. per acre), its sanitary condition is to-day improved by an annual disinfection of 200—250 kilogrammes per hectare (176—220 lb. per acre), accompanied by more abundant manuring; instead of losing the precious time required to form a vineyard, the attacked vines are maintained in a good state of production. There are some that stand this treatment for thirty years, and are in perfect health. In Mouillefert's opinion, neither the cropping treatment, even in big doses, nor the submersion, nor other methods, give anything but incomplete results.

Some insects always escape destruction because the distribution of a gas or a liquid through a layer of soil of unequal composition can never be perfect. If this treatment be not annual, it will be of no use, but annual treatment accomplishes perfectly the end in view, for it then annually frees the vine from the greater number of its parasites, and enables it each year to regenerate its atrophied roots, and to live, therefore, with its parasite without suffering too much from it. Every rational observer must therefore acknowledge that if this process be not perfect, and that plants grafted on vines immune to this insect have been the safeguard of the vine-grower, carbon disulphide has rendered great service by preserving the greater part of the French vines in a good state of production. The pure sulphide, or its solution in water may be used.

**Use of Pure Carbon Disulphide.**—So that the treatment with carbon disulphide may give the desired result, it must be used according to the rules established by numerous experiments, and formulated by our learned professors. The accidents and mishaps that befel certain vine-growers were due to working during bad periods, and on unfit soil. Dr. Colas formulated rules as follow for the use of carbon disulphide: (1) Treat the phylloxera as soon as it appears. (2) Treat the whole of the vines, and not the spots only. (3) Apply carbon disulphide in doses of 18—20 grammes per square metre, say $\frac{2}{3}$ of an oz. (wt.) per square yard. (4) Make injections between the stocks so as to place each of them between four holes, avoiding touching the roots with the injector. (5) Sink the latter only 15—20 centimetres (6—8 inches) deep. (6) Take care to plug the holes immediately after the operation. (7) Always take care to let heavy soils, which retain water a long time, drain after heavy rains and thaws. (8) Avoid treatment at the two seasons of the year when the sap begins to move. (9) Cultivate and manure the vines treated in a suitable manner. (10) Avoid treatment when frost is feared.

These rules have not been appreciably altered up to now. To create around the vine an atmosphere uniformly charged with vapours of carbon disulphide, uniform doses must be made to penetrate into the soil at equal distances. An arrangement of holes as uniform as possible must be chosen, and the treatment applied uniformly over all the extent of ground to be disinfected. Not less than 20,000 holes per hectare (say 8000 holes per acre) must ever be made, nor less than 40,000 (16,000 per acre) in land only slightly permeable. A distance of 30—40 centimetres (12—16 inches) is generally kept from the foot of the vine, so as to avoid wounding the large roots. In many cases, however, deep injections can be made at 20 centimetres from the stock. The amount of sulphide injected per hole depends on the number of injections per square metre. At Libourne, for example, only 12 grammes is injected per hole, say 160 kilogrammes (352 lb.) per hectare (141 lb. per acre), instead of the dose of 200 kilogrammes (440 lb.) per hectare (176 lb. per acre) usually employed in the Rhone, where the vines produce in consequence of this methodical treatment as beautiful crops as before the invasion of the phylloxera. The dose to use depends, moreover, on the depth of soil and the age of the vine. If it be desired to bathe all the root system in a toxic atmosphere, three holes must be made 1·2 metre (4 feet) deep, the roots of certain vines being more than 1 metre (3·28 feet) in length. Cabanel and Degrully, however, advise not to go beyond a depth of 50 centimetres (say 20 inches). In compact soils 20 centimetres (7·8 inches) is enough. When holes are made in the immediate neighbourhood of the stock as the tendency is now, a depth of 8—10 centimetres (3—4 inches) is not exceeded. The greater number of vineyards is treated by the injector. In large vineyards, however, the plough is employed as follows: In vineyards where the lines are a metre (3·28 feet) apart, two turns of the plough are given between the lines. Each line of treatment is 25 centimetres (10 inches) from each row of stocks. In the case of vines planted at greater intervals care is taken to maintain the distance of 25 centimetres from the stocks for the first line, the others are 50—60 centimetres (20—24 inches) from each other, but it is best not to approach the rows of vines too closely, for at 5—10 centimetres (2—4 inches) they suffer from the injections. Sulphuretting ploughs were introduced with great enthusiasm, but they did not give the results anticipated. That is, because in spite of their ingenious arrangement, the carbon disulphide cannot be introduced to any depth, without meeting and wounding the roots. The great advantage of these improved instruments consists in the fact that a man and a horse can treat ½ hectare (1¼ acre) with them in a day. The work, moreover, is very uniform as regards distribution and dose, especially with intermittent jet drainers. The latter, especially, have the great advantage of greatly facilitating the diffusion of carbon disulphide which is projected with force, and which is divided almost instantaneously. The efficiency of the treatment by carbon disulphide depends especially on the nature of the soil, and Degrully is of opinion that there exists for each soil a propitious moment favourable to the uniform distribution of carbon disulphide; this moment should be observed and chosen by the vine-grower. In permeable or sandy soil, cracked or too dry, the carbon disulphide will escape without producing its effect. But in compact moist or clay soils it does not spread enough and remains concentrated around the holes, thus destroying a portion of the roots in their neighbourhood and remaining without effect on a great part of the soil affected. The treatment must therefore be deferred until the soil is neither too moist nor too cracked by the heat.

Although the painstaking observer will always be capable of utilizing the sulphide against the phylloxera in no matter what ground, its use is exclusively recommended in medium ground, neither too light nor too heavy, neither too moist nor too dry. Just as the treatment should never be applied after tillage, which by lightening the soil lets the sulphide evaporate too easily, it is necessary to wait fifteen days before trenching or working. The most favourable time for treatment depends, moreover, on the condition of the vine; although the latter does not suffer from this treatment when the dose is small, yet it is advisable to choose the time when the sap is at rest. October or November is preferably chosen for making injections; February and March are quite as favourable. So that the action of the sulphide be complete, the vine must be allowed to reconstitute its root system by giving it abundant manure, especially mineral. When the vine has been sulphuretted annually from the time of the invasion, it need not receive further care than what it usually gets.

**Use of Carbon Disulphide Dissolved in Water.**—The carbon disulphide used in the beginning of the phylloxeric invasion, having too often caused the death of the vine, it was thought that by dissolving the sulphide in water it would be less hurtful. A saturated solution, *i. e.* containing 0·5—1·2 per cent. of carbon disulphide, is perfectly capable of combating the phylloxera; it kills it in twenty-four hours. The advantages of this method are that it is perfectly harmless to the vine even when it is in full vegetation, and that it can secure a uniform distribution in the soil. According to Degrully, the action of these solutions is the more perfect the more permeable the soil. Under this form the sulphide acts quite as well as potassium sulphocarbonate and has the advantage of being much cheaper; 200 lb. of sulphocarbonate employed in the same conditions as 10 gallons of carbon disulphide, in 1 per cent. solution do not give so good a result. To prepare a solution of sulphide, Fafeur frères have designed an apparatus capable of spreading water on a layer of carbon disulphide, in a closed reservoir. A current of water flows through a pipe of suitable dimension drawn out to a point. The pressure obtained by the drawing out and the speed of the current is exerted on the upper part of a receiver full of water and sulphide which, owing to its density, always occupies the bottom of the receiver. This pressure is transmitted to the receiver by two orifices. The solution is thus produced under pressure in a closed vessel by the junction in a pipe of two jets of sulphide and of water, the intensities of which are always proportional to each other. By opening the gauge taps the dose is regulated from 0·5—1·2 per cent. The sulphuretted water is carried by buckets or a long watering pipe into small holes specially dug round the stocks. These holes should be well made, horizontal, and separated from each other by mounds of earth so that the liquid is spread uniformly in the soil. Working on a large scale steam pumps carry the sulphuretted water several kilometres (kilometre = 0·625 mile) by means of a galvanized iron pipe. The average amount of sulphuretted water for each stock is 20 litres (4·4 gallons), and the solution contains 0·5 per cent. of sulphide in summer and 0·7—1 per cent. in winter. The soil should be returned to its place as soon as possible after treatment.

**Insecticide Irrigations.**—These examined and recommended by Duponchel represent the most improved and rational system. Underground irrigation, already very efficient in itself especially when manure is added to the water, appears to be a method of treatment that can be usefully applied in the treatment of the vine attacked by the phylloxera. But although the ordinary treatment enables the state of diseased vines to be improved, it could not in itself constitute a sufficient remedy to kill the phylloxera and annul the disastrous effects of that insect. Insecticide irrigations have a very salutary effect on vines and fulfil the end in view. Carbon disulphide cannot, in fact, suffice by itself alone to re-establish the health of a diseased vine during drought, or when root growth is stopped. To attain this salutary effect it is necessary to follow up the injections of sulphide, which in destroying the phylloxera suppress the evil by an underground irrigation which causes the effects to disappear by fortifying the roots and giving new vigour to the vine. It is better to combine the two treatments in a single one and to apply simultaneously to the plant, along with the water carbon disulphide and the necessary manures. This method of diffusing the insecticide throughout the whole depth of the soil, in a dose which it is known cannot injure the plant, produces an excellent effect. The irrigations ought to penetrate 20—24 inches into the soil. They require 1000 cubic metres of water per hectare, say 100 kilogrammes (88 lb. per acre) of sulphide, which represents 30 cubic metres (6600 gallons) of sulphide vapour (2640 gallons per acre). A stronger dose would injure the vine, especially during the epoch of vegetation, which lasts eight months. Insecticide irrigation is differentiated from the sulphide treatment by the fact that the first can be applied in the spring, in summer, and in autumn without prejudice to the plant, whilst the latter can only be done during the repose of vegetation. The irrigation water is brought to the culminating point of the vineyard to be treated. At this point it is mixed with the carbon disulphide in a tank, called the bubbling tank, and arranged so that the water charges itself with carbon disulphide without being able to carry away with it what has not been dissolved. The same bubbling apparatus used to dissolve the sulphide may serve for dissolving the manures, so that the water entrains them and distributes them throughout the whole extent of the diseased vineyard. To produce good results the irrigation should be underground and the surface of the soil should be maintained constantly dry and friable by tillage or by hand hoeing, carried out after watering, and renewed each time that rain has strongly packed the soil. To secure good underground distribution it is necessary to lighten the soil by tillage and to open around each stock a small ordinary stripping basin. These basins are connected with each other so that they can be filled in succession. If the tanks have only the slight slope required to ensure the flow of water without a gush, the water introduced into the basins will filter into the soil without moistening the surface layer. As soon as the liquid is completely imbibed, the holes are filled with dry earth and the soil is soon afterwards tilled and hoed. The large quantity of water which these irrigations require renders the treatment almost impossible. But when a spring with an output of a litre a second (13·2 gallons a minute) is available the quantity of water produced suffices to irrigate 10 hectares (25 acres). Underground insecticide irrigations, although useful in all cases, are particularly favourable in the hot countries of the South of France, where it is necessary to ameliorate the hygienic conditions of the vine by moisture to enable it to reconstitute its root system after being freed from the insect which caused the disease.

*Schizoneura lanigera*, Hausm. (woolly aphis).—The disinfection of the branches, as is done by applying various insecticides, is not enough, for there exist underground hot-beds of infection which reinfect the crown of the tree. Carbon disulphide, used in injections round the plant, forms an excellent means of destroying the aphis living on the roots. Taschenberg and Goethe have recommended the use of carbon disulphide to destroy the colonies existing above ground. They advise for this purpose the use of a stick, to the extremity of which a lump of cotton-waste dipped in carbon disulphide is fixed. The woolly aphis can thus be destroyed at all seasons without injuring the apples. The colonies must not be overlooked, and it is advisable to recommence the treatment some time after the first. Targioni and Sorauer recommend soap emulsions for the same object, the first a 2 per cent. carbon disulphide one, and the second a 4 per cent. one. Gold's liquor, recommended for the destruction of the woolly aphis, consists of 20 grammes of [spirits of ?] turpentine, 20 grammes of carbon disulphide, and 60 grammes of curdled milk. Amongst the underground ground lice that often occasion great damage are the—

*Schizoneura grossulariæ*, Schule, which sucks the roots of the gooseberry.

*Aphis Persicæ niger* (the peach tree aphis).—This aphis causes ravages in peach orchards in America.

*Tychea phaseoli*, Pass.—The presence of which, on the roots of haricots, cabbages, and potatoes, sometimes causes them to perish. All these insects may be combated like the phylloxera. The lice which sometimes damage certain plants are successfully combated when it is possible to cover the plant with an awning or a cloche (bell-shaped vessel) under which a few grammes of carbon disulphide are laid. According to Smith all the lice are killed in an hour. Even after twenty-four hours' treatment at the ordinary temperature the plant does not suffer. Soap emulsions, 2—4 per cent., have likewise been applied in a general way, but these latter, which sometimes succeed perfectly, may completely roast the leaves, chiefly those that have been wounded.

*Coccides* (cochineals, kermes).—In a general way the *Coccides* resist carbon disulphide to a greater extent than the *Aphides*, but they do not resist a sulphuretted atmosphere. By destroying the coccis the fumagine (smut of fruit trees) is arrested.

*Coccus vitis*, L., syn. *Pulvinaria vitis* (red coccis of the vine); *Dactylopius vitis* (white coccis of the vine).—Targioni-Tozzetti and Pastre recommend carbon disulphide emulsions.

*Diaspis pentagona*, Targ.-Tozz. (mulberry kermes).—Franceschini recommends for the disinfection of buds to place the branches before detaching them from the tree in an atmosphere of carbon disulphide. With this end in view, the end of the branch is placed in a tight cylinder, where it is left some hours in contact with a toxic atmosphere. This treatment whilst disinfecting the buds is not injurious to them.

Orange scale insects: (1) *Aspidiotus Limoni*, Sign; (2) *Mytilaspis flavescens*, Targ.-Tozz.; (3) *Chrysomphalus minor*.—The first, especially injurious, in Italy induces the fumagine, the last two, imported from America, dot the organs attacked with small yellow spots. Hoffmann recommends spraying with carbon disulphide emulsions, containing 2 per cent. of soap and 2 per cent. of sulphide. Belle advises the destruction of these parasites in greenhouses and pot plants by covering the latter with an awning, and producing a sulphuretted atmosphere, 120 grammes of sulphide sufficing per cubic metre.

*Saperda candida*, F. (round-headed apple-tree borer) is a serious pest of apples and quinces in some parts of Pennsylvania. The remedies suggested are cutting out the borer or killing it with wire and injecting carbon disulphide into the holes, afterwards stopping the holes with clay or soap. Where infestation is severe, a wash of lime-sulphur sludge should be applied in the middle of May and again about mid-June as a repellent.

*Goat Moth.*—Injections into the holes bored in trees by the larva of the goat moth are recommended by the British Ministry of Agriculture.

*Platyedra* (*Pectinophora*) *gossypiella* (pink bollworm).—In St. Vincent experiments were conducted to determine to what depth carbon disulphide would penetrate cotton seed meal and deal effectively with the pink bollworm. Under the conditions of the experiment, the fumigation was effective against the adult moths at a depth of 12 in., against larvæ at 8 in., and against pupæ and eggs at 6 in. A second fumigation would probably be advisable after an interval of from 7 to 10 days, as by that time transformation would have occurred of any eggs and pupæ not killed by the first fumigation. Cotton seed meal could therefore be effectively fumigated in bags with a diameter of 12 in. In the case of cotton seed, the effective range of the fumigant might be greater, as the material is not so closely packed. There are no indications in these experiments that *P. gossypiella* can breed or maintain itself in cotton-seed meal.

*Mammals.*—The rodents which cause damage, such as the mouse, field mouse, ground squirrel, rat, and even the mole, may be destroyed by pouring carbon disulphide into their burrows and stopping the orifices of their nests. It takes 20 grammes (say $\frac{3}{4}$ oz.) for the *Mus sylvaticus*, L., Borghi; 10 grammes (say $\frac{1}{3}$ oz.) for the ground squirrel (*Spermophilus citillus*, Bajor); for rats 60 grammes (say 2 oz.) are necessary. The most radical method consists in steeping rags in carbon disulphide and in inserting them deeply into their holes, which are afterwards plugged with plaster, mortar, or a plug of hay coated with potters' clay.

# CHAPTER IV

## SULPHUROUS ACID—SULPHURIC ACID (OIL OF VITROL)—CHLORINE—HYDROCHLORIC ACID—NITRIC ACID

**Sulphurous Acid,** $SO_2$.—**Preparation.**—This gas is prepared on the large scale by the oxidation of sulphur. When sulphur is heated in contact with air this product burns and is converted into sulphurous acid. Pyrites, or sulphide of iron, which is roasted at a great heat, may also be used to obtain the same acid. That is the process most usually employed. The gas is led into a gasometer, where it is liquefied by cooling.

**Properties.**—Sulphurous acid is colourless and very fluid. It boils at 8° C. below zero; its density is 1·45. Sulphurous acid is not combustible. Its use is, therefore, attended with no risk of fire. Respired in large quantities it induces suffocation, but in small quantities it is not injurious to man.

**Action of Sulphurous Acid on Plants.**—All plants, without exception, suffer in an atmosphere of $SO_2$. The leaves absorb this gas, very much attracted by water, and hydrate it. Almost all the sulphurous acid is retained there, and they are the first to suffer. A very small quantity then passes into the wood of the plant. Under the influence of the solar radiation the hydrated sulphurous acid is transformed into sulphuric acid, with liberation of sulphur, according to Loew's equation :—

$$\begin{array}{ccccccc} 3H_2SO_3 & = & 2H_2SO_4 & + & S & + & H_2O \\ \text{Sulphurous} & & \text{Sulphuric} & & \text{Sul-} & & \text{Water} \\ \text{acid} & & \text{acid} & & \text{phur} & & \end{array}$$

The numerous analyses made on dead plants, after the absorption of sulphurous acid, all, in fact, give abnormal quantities of sulphuric acid.

Wislicenus, who widened the question by very conclusive experiments, believes that sulphurous acid, absorbed by the plant, has no injurious action on the latter, except the plant be full in the light, and especially in full sunlight; in darkness the action is *nil*, although there is absorption of the gas, and in winter the action is very attenuated. According to the experiments, an atmosphere containing a proportion of $\frac{1}{100000}$ of its volume of sulphurous acid kills fir-trees (*sapins*) in about four weeks if they are in contact with this air in full daylight, but these same firs do not appear to suffer if the experiment be repeated in darkness, even if the atmosphere contain $\frac{1}{500000}$ of sulphurous acid. It is thus evident that sulphurous acid is only converted into sulphuric acid under the action of light, and it is the latter acid which is injurious to plants. Agreeing with Von Heine, Wislicenus concludes that sulphuric acid destroys the chlorophyll of the plant, and that it thus acts in a manner unfavourable to assimilation. Sulphuric acid dries the cell-walls and renders them impermeable. Only the tissues in contact with the fibro-vascular bundles remain fresh and green, whilst the others wither, brown, or bleach. In that lies the characteristic symptom of these poisonings. According to Von Heine, the transpiration of the poisoned leaves, the cell-walls of which have become impermeable, is less than that of healthy leaves. As the activity of transpiration expresses the production of matter, the leaf assimilates less, the plant remains stationary, and finally dies. The greater the amount of sulphurous acid absorbed, the more intense the sun, the greater the heat, and the drier the air, the more quickly are these symptoms produced. All leaves, however, do not absorb the same amount of sulphurous acid in the same atmosphere. With equal leaf-surface, those of conifers absorb much less of this gas than those of deciduous trees and herbaceous plants. It was believed that the gas being absorbed by the stomata of the leaf, the quantity retained would be proportional to their number, but experience has shown that it is not so, for leaves absorb this gas quite as well by their upper surface. The herbaceous plants are ranked, according to their sensitiveness to sulphurous acid, between the conifers and the deciduous trees. The leaves of the *Papilionaceæ* (pea tribe), potatoes, cereals, and meadow grass, commence to fade and to brown at their extremities after exposure of two hours in air containing $\frac{1}{40000}$ sulphurous acid; in an atmosphere containing only $\frac{1}{60000}$ of this gas desiccation does not occur until after fifteen to twenty hours. For leaves of deciduous trees to perish the air must contain $\frac{1}{10000}$ to $\frac{1}{20000}$ of sulphurous acid. Conifers in general, and especially firs, do not support air containing more than $\frac{1}{10000}$ to $\frac{1}{20000}$ of this gas, especially in the neighbourhood of factories. This small quantity of sulphurous acid necessary to cause a pathological condition of the plant is the reason why each factory chimney must be regarded as a perpetual hot-bed of infection. The smoke from the combustion of coal contains on an average 0·01 to 0·02 of sulphurous acid gas. The danger is obviated if the smoke is sent into the air by chimneys measuring 20 metres, say 65 feet, in height. The following, for example, shows the deterioration undergone by a field of oats situated near a coke factory. One thousand seeds of normal oats ought to weigh, on an average, 25 -29 grammes; 1000 grains in the sickly field only weighed 14·76 grammes. Both the grain and the straw in this field were analysed, and in both instances a large amount of sulphuric acid was found. Such damage to crops is particularly intensified around chemical factories, chiefly sulphuric acid factories, where pyrites is roasted, and zinc factories, in which blende, zinc sulphide, is calcined. The deadly action of the sulphurous acid sent into the air by these factories manifests itself at great distances. Forests 5 kilometres, say 3¼ miles, away still suffer from their proximity. A zinc works calcining 50 tons of blende disengages 37,000 hectolitres (814,000 gallons) of sulphurous acid. It will be seen that this amount of toxic gas, if not utilized, may carry devastation to great distances. Many observations have been made on this point, and it is found that near (such) factories the leaves of the fir (? spruce) fall, those of the pine and larch, more resistant, only brown at the point, and the trunk blackens; conifers, in general, do not resist long. Deciduous trees, fruit trees, among others, lose their leaves and do not produce fruit, because the sulphurous acid sterilizes their flowers. The cornfields are sickly, patchy; the brown-coloured ears contain no grain. Haricots and cabbages are spotted white and suffer much. The dead leaves of the potato shrivel and blacken. The meadows remain sickly and turn brown. These sickly plants all contained an abnormal dose of sulphuric acid. It is important to insist on these facts, so as to show the injurious action of sulphurous acid on plants. Knowing this fact it is an easier task to contradict the opinion generally held that sulphur acts on fungi by its conversion into sulphurous acid. If it were so our vineyards, instead of becoming more vigorous by sulphuring, would perish, since an infinitesimal quantity of acid suffices to roast plants, and fructification, instead of being stimulated as is the case, would be diminished.

**Action on Fungi**.—It follows from observations made on plants that those which contain chlorophyll are more sensitive to the action of sulphurous acid than those deprived of it. Sulphurous acid cannot therefore be used to destroy fungi.

**Action on Insects**. –To stifle insects the air must be saturated with $SO_2$. Great care must therefore be taken in using this gas so as to avoid its deadly action on plants. The great delicacy of the operation renders it less and less popular, hence the clochage of the vine still in use in certain districts is gradually being replaced by scalding. The phylloxera does not persist for twenty-four hours in an atmosphere of this gas of 1 in 60 or 1 in 100. Mouillefert tested it in the soil against phylloxera but without result. Moisture and the nature of the soil destroy its toxic properties.

**Use in Diseases Treated by $SO_2$ in the Open Air.**—*Gum Disease.*—Swingle and Webber who examined the action of different chemicals on this disease recommend to cure it, to clean the wounds and coat them with an 18 per cent. solution of $SO_2$.

*Anthonomus Pyri*,[1] Boh., *Anthonomus pomorum.*[1]—These formidable destroyers may be removed in May by $SO_2$ fumigations (Poupinel). A dish of burning sulphur is moved about under the branches, or rags dipped in molten sulphur and then lit. The trees should not be fumigated with $SO_2$ when in blossom, as the flowers would be sterilized even if the contact was short and the acid in very small quantity.

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[1] Anthonome of the Apple-Tree. *Apple blossom weevil, Anthonomus pomorum.*—Length, 4 millimetres; colour, blackish-brown, with short, compact hairs forming a down; rostrum arched. The adult insect lives the whole year at the expense of the apple leaves. In the spring the female pierces a hole in the floral envelopes and deposits an egg in each flower bud until finished, laying thirty eggs at least. After an incubation of five to eight days the larva is hatched and attaches itself forthwith to the stamens and pistils of the flower, thus destroying the essential organs of the latter. The French gardeners call the browned buds cloves. Anthonome of the Cherry-Tree. *Anthonomus druparum.*—Brown weevil of 5 millimetres which lays its eggs in the flower buds of cherry-trees. Anthonome of the Pear-Tree. *Anthonomus Pyri.*—Weevil very similar to anthonome of the apple-tree, but it lays its eggs in the floral buds of the pear-tree before and not during winter. Its larva is what gardeners call the *winter-worm.*

Such fumigations also asphyxiate the grubs injurious to fruit trees, who know how to shelter themselves from spraying in the common nests which they spin. The most injurious are *Hyponomeuta Malinella*,[1] Zell. (small ermine moth) and *Liparis chrysorrhœa* (brown tail moth). The grubs of these butterflies are only sensitive to fumes of $SO_2$. Dufour proved by trial that liquid $SO_2$ does not act on the grubs, and that even a 20 per cent. solution does not kill those of the *cochylis*.

*Phylloxera vastatrix* (vine phylloxera). –The phylloxera dies if exposed for twenty-four hours in an atmosphere containing 1 per cent. of $SO_2$. Hence it was thought the injection of $SO_2$ in the soil would destroy this injurious insect. A. Vigié recommended injections into the soil of a mixture of sulphur and sulphur fumes from the beginning of the phylloxera invasion. Henneguy remarked that when this treatment was applied in summer the spread of the disease was circumscribed, and although this process may be insufficient to free the vine entirely from its parasite, it destroys it to such an extent as even to allow the vine to thrive. Mouillefert examined the effect of $SO_2$ both as gas and in solution, as well as its different salts. He found that sulphites are quite powerless against the phylloxera. As to gaseous $SO_2$ it has no action on insects near the surface of the soil because this gas, with a great affinity for water, can never penetrate deep enough into the soil.

*Mus Ratus*, L. (Rat).—M. A. ter Mer advises the use of $SO_2$ to kill rats. Rags are dipped in molten sulphur and petroleum, these are inserted into the burrows and lit. It requires about ½ lb. of sulphur per burrow. Taschenberg dissents; he found that this method failed, even if the gas is driven far into the burrows by means of special bellows.

**Use of $SO_2$ in Closed Spaces.**—The action of $SO_2$ is deadly to insects when the air is saturated with it. It is used especially in granaries against the Coleoptera and Lepidoptera injurious to the stored grain. It has also been used on small trees which can be covered with a tent or a cloche. The last method is used especially to combat the *cochylis* of the vine.

*Mycogone perniciosa*[2] (mole disease of the mushroom bed), *Psalliota campestris*, L. –Constantin and Dufour found that the spores of the *Mycogone* are killed by prolonged contact with $SO_2$. Mushrooms are in no way injured in an atmosphere containing this gas, even if the fumigation lasts twenty-four hours.

*Hops.*—The preservation of stored hops is not always an easy matter. Disinfection with $SO_2$ does not always give the result expected. Behrens found that if $SO_2$ be incapable of killing the germs of the parasite which infest hops, it has a good effect on their quality, which it alters for the better. But it is chiefly against the invasion of Coleoptera into granaries and on the vine that $SO_2$ does good work. Amongst these insects are :—

*Calandra granaria* (or wheat-weevil).—As a curative method fumigation with $SO_2$ is used. The doors and windows of the granary are closed; sulphur is then ignited in a vessel placed on a support above a sheet of iron; 1500 grammes (3·3 lb.) of sulphur with 100 grammes (·22 lb.) of saltpetre, suffice to disinfect a space of 50 cubic metres. The granary is left closed for twenty-four hours, then it is cleansed with a 2 per cent solution of corrosive sublimate. The same process is used to destroy *Microlepidoptera*, the grubs of which ravage grain and flour granaries.

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[1] HYPONOMEUTA MALINELLA (small ermine moth), HYPONOMEUTE OF THE APPLE-TREE (tinea of the apple-tree).—Small imago the upper wings of which are white and covered with black spots.

[2] MYCOGONE PERNICIOSA (mole disease of the mushroom).—Mushrooms attacked by the mole grow in an irregular manner, swell, puff up, and become deformed to such a pitch as to be nothing but an irregular-shaped mass. This mass is covered in places by white spots and easily rots.

*Sitotraga cereallela* (grain mite).—So that the $SO_2$ may penetrate well into the heap of wheat and kill all the grubs, Saint Ubery burns the sulphur in chafing dishes around which the grain is piled in heaps. To destroy butterflies the process used against the *Calander* gives good results. It suffices to place 1 inch to 1½ inch of sulphured wick on slates laid on the heap of wheat, and to set fire to the wick. By analogy it was thought possible to destroy by the same gas the grubs which live in flour.

*Asopia farinalis* (flour mite).—The process recommended by Debray consists in burning in closed vessels 60 grammes of sulphur per cubic metre of flour; the method was regarded as obnoxious, the flour being rendered unfit for bread-making; Balland found this flour, whilst presenting no visible alteration, is appreciably altered in contact with sulphurous acid. The gluten has lost the valuable properties required in baking. It is recognized, in fact, that gluten gains in value by contact with alum, common salt, or blue vitrol, but that it cannot stand the action of sulphurous acid, $SO_2$, nor sulphuric acid, $SO_3$, nor sulphuretted hydrogen, $SH_2$. To destroy the tinea of grain, $SO_2$ must not be used, but insecticides like $CS_2$.

*Tortrix* or *Pyralis vitana* (pyralis of the vine).—The grubs hibernating in the fissures of the bark of the vines can be killed by $SO_2$. The process employed in the South of France is known by the name of *clochage*, or sulphuring of the vine. After pruning the vine, each stock is covered by a zinc cloche, or half a petroleum barrel, under which 20—25 grammes of sulphur (say ¾ oz.) are burnt in a saucer. The $SO_2$ formed soon saturates the air under the cloche, and stifles the grubs sheltered in the interstices of the bark. The operation should not last longer than five to ten minutes, a more prolonged action having a deadly effect on the vine. A workman provided with twenty cloches can sulphur 1000 stocks per day. It is a very delicate operation, which may well be replaced by scalding, but its use is still widespread. So that it may succeed, it must not be done when the soil is noist, for the $SO_2$, instead of saturating the air, would be absorbed by the humidity in the soil. Clochage kills, at the same time as the pyralis, the vine coccis and the red spider. Reh found that all coccides shielded Homoptera, such as *Diaspis*, *Aspidiotes*, *Lecanium*, *Ceroplastes*, and coccides, which resist all insecticide spraying, may be destroyed by $SO_2$ fumes. The fruit trees are covered with a tent, and sulphur burnt therein, observing the same precautions as in the clochage of the vine.

**Sulphuric Acid,** $H_2SO_4$.—Sulphuric acid is obtained by passing a mixture of oxygen and sulphurous acid over spongy platinum or platinized abestos, heated to between 250° C. and 500° C. (482—932° F.). The vapours of $SO_3$ disengaged are led into a receiver surrounded by a freezing mixture, where they condense. The process of manufacture usually adopted is to oxidise sulphurous acid by nitric acid vapours and to hydrate the vapours in lead chambers. The necessary $SO_3$ is obtained by "burning" iron pyrites in presence of an excess of air.

**Properties.**—The commerical acid of 66° B. (168° Tw.) is a colourless, odorous, viscous, oily liquid of sp. gr. 1·84. When water is mixed with the acid so much heat is developed that it may become dangerous if the water is added to the acid. Care must therefore be taken in diluting the acid with water to run the acid gently into the right amount of water with constant stirring. $H_2SO_4$ has a great affinity for water, and rapidly carbonizes organic matter.

**Action of Sulphuric Acid on Plants.**—This acid exerts a corrosive action on the organs of the plants touched by it. A very small dose of this acid (even dilute) destroys the chlorophyll and degenerates the cell-walls, thus giving rise to a profound disturbance in the life of the plant.

*Transpiration* is less abundant, and that of itself diminishes or even abolishes completely the production of synthetic organic matter, the leaves brown, wither, fall, and the growth of the plant is visibly arrested. If the action of this acid on a plant be prolonged it soon dies, for the acid penetrates rapidly into the interior of the trunk, and the circulation of the sap is stopped. The same result occurs when a plant is in contact not only with the dilute acid but also with sublimed sulphur, which contains $H_2SO_3$, and under the influence of sunlight is converted into $H_2SO_4$ in the leaf itself.

**Action of Sulphuric Acid on Fungi.**—Plants not containing chlorophyll suffer much less than green plants in contact with $H_2SO_4$. However, owing to its hygroscopic nature, $H_2SO_4$ diluted to 0·5 per cent. exerts a corrosive action on fungi. Laboratory trials made by dipping the spores into a drop of $H_2SO_4$ diluted to 0·5 per cent. show that such dilute acid destroys in most instances the vitality of the spores, provided that its action be sufficiently prolonged. In practice the 0·5 per cent. acid is quite inadequate to destroy the spores and mycelium of fungi, and stronger, sometimes even the 168° Tw. acid must be used. It will be easily seen that at that degree of concentration $H_2SO_4$ cannot be put in contact with the leaves of plants, and that it should be limited to applications on the trunk, or to disinfect certain seeds; in a wood it can only be used when there is no active plant growth. Under such conditions, plants do not appear to suffer from sulphuric acid treatment. When $H_2SO_4$ is used in combination with anti-cryptogamic metallic salts, its corrosive properties become valuable, because in attacking the protective membrane of the parasites it enables the poison to reach and destroy them more readily. In combination with green vitriol in the winter treatment of anthracnose of the vine, sulphuric acid is in current use, and of great service.

**Use against Parasitic Fungi.**—Sulphuric acid has been recommended for some years to wash seeds to free them from the spores of different fungi which might be brought on to cultivated land. Noel found that steeping in the 0·5 per cent acid sufficed to free seed-corn from anthracogenous parasites. He stirred up a hectolitre ($2\frac{3}{4}$ bushels) in 22 gallons of 0·5 per cent. acid, and sowed immediately afterwards.

This method has since been tested by specialists of high reputation and found deficient. Kuhn has shown that not only was the 0·5 per cent. acid an anodyne for the spores, but had the drawback of being more injurious than sulphate of copper. The injurious action of the acid on cereal grains does not make itself felt for some time. Such seed-corn always retaining a little sulphuric acid cannot dry up completely and rot. This drawback may be avoided if care be taken to wash the seed in milk of lime immediately after steeping in the acid. In fact, Boiret found that the spores of bunt were not completely destroyed after a twenty-four hours' steep in a 5 per cent. acid, and that a 20 per cent. acid destroys the grains of wheat without killing the germs of the disease, even if steeped six hours therein. All cereal grains are thus sensitive to the action of $H_2SO_4$; however, amongst the different species of wheat there are some which stand the acid better than others.

TABLE XI.—*Effect of Steeping Seed Wheat for Different Lengths of Time in Dilute Sulphuric Acid on Germinative Capacity per cent.*

| Sulphuric acid. | Duration. | Golden drop. | Garter. |
|---|---|---|---|
| 1 per cent. . . | 24 | — | 18 |
| 2 ,, . . | 12 | 40 | 14 |
| 2 ,, . . | 8 | — | 18 |
| 5 ,, . . | 2 | 90 | — |
| 5 ,, . . | 1 | 92 | 60 |
| Steeped in water . | — | — | 90 |

It follows that this acid does not possess the requisite properties to replace blue vitrol in the pickling of seed corn. The only seeds that can stand steeping in the acid are beet-seeds, which are surrounded by a protecting sheath which enables them to stand steeping in acid of 66° Bé. (168° Tw.) without their germinative capacity being diminished. This protecting sheath acts as a shelter to the germs of fungi and bacteria of the most diverse nature, such as *Phoma tabifica*, Prill. et Delacr.; *Pythium de Baryanum*, Hesse; *Bacillus mycoides, Bacillus butyricus*, *Proteus vulgaris*. As soon as the radicle and cotyledons of the beet appear these fungi invade them, disturb the normal evolution and induce rot. Hiltner found that the 30—35° Bé. acid will destroy the germs of all these parasites. Linhart recommends 66° Bé. (168° Tw.) acid in which the seed is steeped half an hour, then washed ten minutes with a jet of water, then the seeds are dipped into milk of lime, and all that now remains to be done is to wash the seed for four hours in running water. The seeds so treated are in no wise injured. Their germinative capacity is increased; they spring up more rapidly and in larger quantity, and the disease germs are completely destroyed. For reference purposes a description is here given of the researches published on the resistance of spores of different fungi to dilute $H_2SO_4$. These laboratory trials were made by incorporating the spores of rust and of caries with a drop of dilute sulphuric acid, which after being a certain time in the acid were sown or examined by the microscope. Kuhn examined the action of sulphuric acid on the spores of the caries of wheat, and he found that acid of the same strength is not capable of killing in the same time the different spores of caries. A 5 per cent. acid acted thus :—

TABLE XII.—*Showing the Action of Dilute Sulphuric Acid of 0·5 per cent. Strength on the Spores of Oats and Wheat.*

| Duration of action. | Oats. | Wheat. |
|---|---|---|
| 1 hour | Numerous living spores . . | Numerous living spores. |
| 6 hours | Living spores less numerous . | ,, ,, |
| 8 ,, | Very few living spores . . | ,, ,, |
| 10 ,, | All spores killed . . . | ,, ,, |

Wuthrich examined the action of different acids, compared with that of metallic salts, on the spores of—

*Ustilago Carbo*, Tul. (smut of grain crops).—In a 0·49 per cent. sulphuric acid all spores are killed after fifteen hours' action at 20—22° C. An acid of 0·049 greatly prevents the formation of zoospores, whilst acid of 0·049 per cent. has no longer any injurious action on the spores themselves. Herzberg examined the different rusts, and submitted their spores to the action of sulphuric acid of various strengths. The spores of *Ustilago Jensenii*, Rost., the smut of barley, were found to be the most resistant. To kill these spores they must be stepped fifteen hours in 3 per cent. acid, whilst those of the other *Ustilaginæ* are killed in much weaker acid. Moreover, the dilute acid has not the same action on the spores of the same species but of different ages; the mortal dose is given in the following table :—

TABLE XIII.—*Showing the Strength per cent. of Sulphuric Acid required to Kill the Spores by Smut of Barley, Oats, and Wheat of Different Ages.*

| Species. | Strength of sulphuric acid. Per cent. | |
|---|---|---|
| | Old spores. | Young spores. |
| Ustilago Jensenii, Rost . . | 1—1·5 | 2—4 |
| ,, Avenæ, Rost. . . | 0·5—0·75 | 0·5 —0·75 |
| ,, perennans, Rost. . | 0·1—0·25 | 0·25—0·5 |
| ,, hordei, Bref. . . | 0·5—0·75 | 0·5 —0·75 |
| ,, tritici, Jens. . . | 0·5—0·75 | 0·25—0·5 |
| Circumambient temperature . | 15—18° C. | 23° C. |

*Puccinia graminis* (black stem rust, summer wheat mildew); *Puccinia Rubigo-vera*, DC. (orange leaf rust, spring rust of corn); *Puccinia coronata*, Corda (the crown rust of oats).—Wuthrich made a comparative examination of these three rusts, by submitting in turn their uredospores and their æcidiospores to the action of the more or less dilute acid. The time of steeping was fifteen hours, and the temperature 20—21° C. (68—69·8° F.). The uredospores resisted an acid ten times stronger than the æcidiospores; acid of 0·0049 per cent. does not act on uredospores of 0·049 per cent.; its action begins to make itself felt, but it is not until 4·9 per cent. acid is used that all vitality is removed from the spores. The æcidiospores are completely destroyed, and in the same conditions, by acid of 0·49 per cent. strength. The uredospores of the rust of cereals would appear to be the spores most resistant to the action of sulphuric acid, as they likewise are to anti-cryptogamic salts. Hitchcock and Carleton have, however, prevented the uredospores from germinating, by steeping them for seventeen to nineteen hours in 0·1 per cent. acid.

*Claviceps purpurea*, Tul. (ergot of rye).—The action of the acid on this disease was examined by Wuthrich, who found that 0·049 per cent. acid attentuated the germination of the conidia, but it required steeping for fifteen hours at 20—21° C. (68—69·8° F.) in an acid of 0·49 per cent. to stop this germination completely. Wuthrich, who examined the action of the acid on the spores of *Phytophthora* and of *Peronospora*, found these latter much more sensitive than those of the black and red rust of cereals.

*Phytophthora infestans*,[1] de By. (potato disease).—Acid of 0·049 per cent. perceptibly diminishes the capacity of the conidia to form zoospores. It may be entirely arrested by destroying the conidia, by using 0·049 per cent. acid for fifteen hours at 19—20° C. (66·2—68° F.).

*Peronospora viticola*, de By. (vine mildew).—The conidia and the zoospores of this parasite behave like those of the *Phytophthora*; acid of 0·049 per cent. completely annihilates them in fifteen hours at 20° C. (68° F.). In 0·0049 per cent. acid the formation of zoospores may be restricted, and even suppressed, without the conidia being killed. The latter then germinate and produce directly a germinative tube. The deleterious action of sulphuric acid on the germs of mildew has caused it to be used for the winter treatment of vine stocks. Bouchard got good results by treating the vines in the spring after pruning with a 10 per cent. acid. During three years the vines received no other treatment than the above, and the disease did not reappear. Acidulated solutions of green vitriol used everywhere against anthracnosis cause no injury to the stocks.

*Gloeosporium ampelophagum*, Sacc. (grape rot).—To combat this disease the utility of the acid was found empirically. It is not, it must be understood, a question of treating this disease during the growing period, for sulphuric acid, or even the acid mixtures, would have a deplorable action on the stocks. The acid is used exclusively in winter to cauterize the spots hollowed out of the young wood, sorts of canker produced by the anthracnose containing spores which should be considered as hot-beds of infection. The remedy most generally used is a 50 per cent. green vitriol solution, but to intensify its action it is associated with sulphuric acid in the proportion of 1 to 2 per cent. Fifty kilogrammes, say 1 cwt., of green vitriol are taken, and 1 litre, say 4 lb., of sulphuric acid are poured on to it and the whole dissolved in 100 litres (22 gallons) of hot water. However, many vine-growers limit themselves to sulphuric acid and regard it as sufficient to circumscribe the disease. It is certain that it kills not only the spores of this disease but also those of the oidium. It is important to operate before budding-time, so as not to injure the growth. It is necessary to imbibe the stems, the runners, and all the wood, and even the eyes. The latter, owing to this treatment, blossom, it is true, some days later than non-treated vines, but this in many cases is an advantage. The coat may be applied with a brush or with a woollen rag.

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[1] POTATO DISEASE. *Phytophthora infestans.*—The fungus which is the cause of this disease attacks the leaves, the stems, and the tubers of the potato. The disease appears first on the leaves and the stems where it shows as brown spots which end by entirely covering them. In wet weather it spreads rapidly and may then destroy the plant.

*Sphærella fragariæ*, Sacc. (strawberry leaf blight).—Galloway recommends the following energetic treatment to destroy this disease: Spray the strawberries after gathering the crop with 2 per cent. acid, which kills both the old leaves and the spores of the parasite. The new leaves which spring up are perfectly healthy. Tyron found this treatment to give as good results as Bordeaux bouillie or alkaline sulphides.

*Cuscuta*[1] (Dodder).—Wagenblicher found that 0·5 per cent. acid killed dodder, but when used on fields of trefoil and lucerne against *Cuscuta Epithymum* the burning of the plant injured the crop. As a weed-killer on walks sulphuric acid is defective. The effect is immediate but the weeds soon sprung up as vigorously as ever. Finally, sulphuric acid has been prescribed against potato scab. Wilfarth, acting on the principle that ashes and lime induce this disease, tried to produce a contrary effect by spreading sulphuric acid on the fields. He therefore spread sulfarine, a mixture composed of magnesium sulphate and of 15 per cent. sulphuric acid. The results were decisive, as shown in the following table:—

TABLE XIV.—*Showing the Action of Different Doses of Sulfarine (kieserite) containing 15 per cent. of Sulphuric Acid on the Potato Disease.*

| Dose. | Crop. | Per cent. diseased. |
|---|---|---|
| Blank | 76 potatoes of which | 80 diseased |
| 2 kg. of sulfarine per m.$^2$ | 77 ,, ,, | 60 ,, |
| 7 ,, ,, | 76½ ,, ,, | 40 ,, |
| 10 ,, ,, | 73 ,, ,, | 25 ,, |
| 14 ,, ,, | 73 ,, ,, | 20 ,, |
| 18 ,, ,, | 65 ,, ,, | 10 ,, |
| 30 ,, ,, | 50½ ,, ,, | 5 ,, |

The disease is, in fact, considerably diminished by this treatment, but the dose of 14 kilogrammes of sulfarine per square metre must not be exceeded, for there would be the risk of too small a crop which would be as great an evil.

[1] CUSCUTA EPITHYMUM (dodder of trefoil and lucerne).—These plants, which are deprived of roots and of chlorophyll, are essentially parasites of other plants from which they draw nourishment by numerous suckers.

**Use of Sulphuric Acid against Insects and Worms.**—*Tylenchus tritica* [1] [Bastian] (eel-worm of wheat).—This is a microscopic worm which causes the blight known in France as Nielle de Froment [and in Great Britain as "Ear Cockles," "Purples," "False Ergot," "Galls of Wheat Eel-worms"]. Davaine recommended steeping the affected grain in 0·5 per cent. sulphuric acid for twenty-four hours, but this method has the drawback of injuring the grain.

*Tortrix vitana* (pyralis of the vine).—The winter treatment against anthracnose of the vine by sulphuric acid, not only destroys the spores of the most formidable cryptogamic parasites, but according to Debray it also destroys the grubs of this butterfly which pass the winter in the interstices of the bark. According to the same observer the vine cochineal *Dactylopius vitis,* which passes the winter fixed against the wood, may be destroyed by spraying with 10 per cent. acid after the fall of the leaf. The acid employed under like conditions to destroy the *Schizoneura lanigera*, Haus, did not give the result expected. To kill *wasps* it suffices to pour 10—20 per cent. acid into the nest.

**Chlorine,** $Cl_2$.—Chlorine is an element widely distributed in nature in combination with certain metals—sodium, potassium, magnesium.

**Preparation.**—By the action of aqueous hydrochloric acid on manganese dioxide, or by the electrolysis of sodium chloride in solution.

**Use.**—This gas, of some use to kill fungi, is so poisonous to plants that its use is limited to saprophytic fungi, such as—

*Merulius lacrymans*,[2] Schm. (dry rot of wood).—As a remedy chlorine is the subject of a German patent, D.R.-P. 76877, according to which good results are obtained by piercing boards with holes into which chlorine is introduced; these holes are then stopped up hermetically.

**Hydrochloric Acid,** HCl.—**Preparation.**—The industrial preparation of this acid is subsidiary to the manufacture of sulphate of soda, intended for the production of soda ash. It is produced by decomposing common salt by sulphuric acid.

$$\underset{\text{Sodium chloride.}}{2NaCl} + \underset{\text{Sulphuric acid.}}{H_2SO_4} = \underset{\text{Sodium sulphate.}}{Na_2SO_4} + \underset{\text{Hydrochloric acid.}}{2HCl}$$

The salt is introduced into capacious cast-iron cylinders, luted with clay, and then sulphuric acid is run on to it. The hydrochloric acid which escapes is dissolved in earthen carboys containing water. Commercial HCl marks 22° by Baumé's hydrometer.

**Use.**—The searching examinations which have been made into the action of this acid on fungi have shown that its use is not advisable, because its action on plants is deadly. Bolley, in 1894, tried to use the anticryptogamic properties of hydrochloric acid against potato scab. The germs of this disease are killed, it is true, by steeping from five to twenty-four hours in a 2 per cent. solution of this acid, but the eyes of the potato suffer so badly that this method cannot be advantageously used. Wuthrich, in a research published in 1892 on the action of metallic salts and acids on the spores of different fungi, proved that the amount of this acid required to prevent the germination of spores compared with that of sulphuric acid used is proportional to their chemical equivalents. Thus a solution of 0·0036 of HCl has the same anticryptogamic effect as a solution of 0·0049 per cent. of $H_2SO_4$. A solution of HCl of 0·0036 per cent. of sulphuric acid prevents germination of the conidia and zoospores of *Phytophthora infestans*, de By.; the conidia and the zoospores of *Peronospora viticola*, de By.; the spores of *Ustilago carbo*, Tul. But to prevent the germination of the uredospores of *Puccinia graminis*, Pers., acid of 0·036 per cent. is required. Hydrochloric acid can replace sulphuric acid wherever the latter has given good results, if the plant be not unfortunately as sensitive as the spores of fungi.

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[1] TYLENCHUS TRITICA ("ear cockles," "purples," "false ergot," galls of wheat, eel-worms of wheat).—The eel-worm of wheat is a very small filiform worm with a smooth tegument which twists its body like an eel, hence the name given to it; length 3 millimetres. The ears attacked in place of ordinary grain have small, rounded, blackish grains like smutty grains.

[2] MERULIUS LACRYMANS (dry rot).—This fungus, allied to the Polypora, is the most dreadful destroyer of building timber. It chiefly attacks resinous woods and produces the dry rot of pine timber and pitch-pine.

**Action of Chlorine and Hydrochloric Acid on Plants.**—Hydrochloric acid and bleaching-powder factories discharge chlorine and hydrochloric acid vapours into the air. The injurious effect of this gas makes itself felt sometimes two miles from the factory, a radius within which it kills plants. This gas is even more poisonous than sulphurous acid itself; deciduous trees suffer as well as evergreens. The pathological condition of the plant attacked is distinguished by the brown border which forms on the leaves; then they are covered with brown spots. The needles of spruce fir trees become yellow at the point, dry up, and drop off. The analysis of the dry substance of the diseased plant twenty-five minutes distant from these factories, according to König, Steffeck, and Heine, gave the following results:—

TABLE XV.—*Showing the Effect on the Chlorine Content of Forest Timber of Proximity to a Hydrochloric Acid Works.*

| Tree. | Condition. | Per cent. chlorine. | Increase in chlorine per cent. |
|---|---|---|---|
| Oak . . . . | Healthy | 0·081 | |
| | Sickly | 0·191 | 135·8 |
| Beech . . . | Healthy | 0·211 | |
| | Sickly | 0·311 | 71·14 |
| Larch . . . | Healthy | 0·279 | |
| | Sickly | 0·767 | 174·91 |
| Spruce . . . | Healthy | 0·101 | |
| | Sickly | 0·132 | 30·69 |
| Hazel . . . | Healthy | 0·178 | |
| | Sickly | 0·516 | 189·88 |

These analyses show that the disease is produced by the absorption of chlorine and hydrochloric acid.

**Nitric Acid.—Preparation.**—The commercial acid is prepared by introducing into a cast-iron pan 330 kilogrammes (726 lb.) of nitrate of soda and 420 kilogrammes (964 lb.) of sulphuric acid of 62° Baumé; the lid is luted with clay and heated. The nitric acid vapours disengage through an earthen pipe, condense in big carboys, also of earthenware, placed one after the other, and each containing a little water. There are thus obtained 440 kilogrammes (968 lb.) of nitric acid of 36° Baumé. Nitric acid is also now obtained in connection with processes for the fixation of atmospheric nitrogen.

**Properties.**—Nitric acid is a colourless liquid, sometimes yellow from the presence of nitrous acid. Its density is 1·52, its boiling-point is 86° C. It is very corrosive; in contact with organic matters it first produces nitrated compounds, then an oxidation which proceeds so far as destruction. It is quite as dangerous as sulphuric acid, and should be handled with many precautions.

**Action of Nitric Acid on Plants.**—The following are the results of the examination of nitric acids on plants: 0·05 gramme of this acid in a cubic metre of air produces poisonous effects on plants analogous to those produced by sulphurous acid; spots and brown borders on the leaves; yellow points on the needles of the conifers. The normal dose of nitric acid in the air is 0·00003 per cubic metre; it therefore requires a dose almost 2000 times stronger to produce pathological symptoms in the plant such as occur in the neighbourhood of factories which allow the vapour of these acids to escape.

**Use.**—Nitric acid is not only corrosive but poisonous to insects. This latter property is manifested, more especially, in organic compounds containing one or more nitro groups. Nitric acid, like sulphuric acid, has been recommended especially to combat insects in winter. Its action on fungi is especially injurious. Hitchcock and Carleton found that the uredospores of *Puccinia coronata*, Corda (crown rust of oats) are killed in twenty-four to twenty-six hours in nitric acid of 0·68 per cent., but an acid of 0·068 per cent. has no action on these spores.

The spores of *Phytophthora* and *Peronospora*, according to present knowledge, are destroyed by an acid of about 0·05 per cent. Nitric acid is not used to combat fungoid parasites except *black rot*, although it has been tried against several other cryptogams.

*Guignardia Bidwelli*, Viala et Ravaz (black rot).[1]—Viala proposed to replace sulphuric acid in the winter treatment of the vine by nitric acid, which destroys the spores of this fungus. Against *insects* Lemoine recommended for the treatment of the phylloxera the coating of the stems with a mixture consisting of 1 kilogramme of nitric acid of 60 per cent., 2 grammes of spirits of turpentine, and 4 grammes of chrome yellow, the whole diluted in 5 litres of water. Examined by the commission who investigated the chemical products proposed to combat this insect the above mixture was pronounced defective.

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[1] Black Rot of the Grape. *Guignardia Bidwelli.*—This disease is due to the parasitism of a Sphæriaceæ which in succession shows *conidia* fruit and *asci* fruit. On the stalks of the leaves black rot shows itself by reddish, more or less circular, well-defined spots. These spots, small at first, become larger and finally run into large black spots consisting of conidia fruits. These same spots are formed on the branches, on the cluster of grapes and on the grapes themselves.

At the present time it is recognized that nitric acid is very injurious to grubs and may be used wherever these are not on the vegetative part of the plant. By this method the grubs of the *Tortrix vitana* (pyralis of the vine) and the *Cochylis ambignella*, Hubn. (cochylis of the vine), which pass the winter in the fissures of the bark of the stem, may be destroyed.

Although Dufour's experiments, which could not destroy the grubs of the *cochylis* by steeping them for some seconds in 50 per cent. nitric acid, do not speak in favour of the insecticide action of this acid, the results obtained in actual practice have been very favourable. Sourdon and Castel, as well as Debray, have recommended for the winter treatment of the vine the use of commercial nitric acid diluted with six times its weight of water. After having barked the vine by Sabaté's iron glove, the eyes, the runners, and the body of the stem are coated with nitric acid. The method may be applied in all weathers, and its efficacy is almost always absolute. Debray is of opinion that nitric acid may replace *ebouillantage*, "scalding," which is a complicated method, and often inapplicable. Like the latter, it frees the vine from all cryptogamic parasites, and from all insects which seek a refuge in winter in the corners of the bark. Barbut's observations which induced him to affirm that 10 per cent. nitric acid only kills 50 per cent. of *pyralis* and 40 per cent. of *cochylis*, that the chrysales of *pyralis* can stand steeping in that acid for several hours without injury, and that treatment by nitric acid retards, moreover, the growth of the vine, in no way diminishes the good results obtained in actual practice, and the success of the winter treatment of the vine by nitric acid.

# CHAPTER V

## PHOSPHORUS—PHOSPHORETTED HYDROGEN—ARSENIOUS ACID—WHITE ARSENIC—ARSENIC ACID

**Phosphorus.—Preparation.**—Phosphorus does not occur in nature in the free state, but as phosphoric acid combined with various metallic oxides, lime, magnesia, soda, etc. In the industrial manufacture bones form the raw material.

**Properties.**—Phosphorus, insoluble in water and alcohol, dissolves in carbon disulphide. It is highly combustible. It oxidizes in the air at the ordinary temperature but does not ignite below 60° C. (140° F.). It melts at 44° C. (111·2° F.). It is preserved under water. Phosphorus is a violent poison which, when absorbed even in very small doses, induces vomiting and epigastric pains. It may act if it continue to be absorbed on the nervous system, which it depresses, and by paralysing the heart's action, it rapidly causes death. The intensity of the action of phosphorus depends on the form under which it is ingested; dissolved in oil, for example, it is much more poisonous than when in solution in other solvents, because in this form it is precipitated less easily in the aqueous juices of the stomach.

**Use.**—Phosphorus is as violent a poison for mammals as for insects. It is used everywhere where pastes can be used to destroy noxious animals. To prepare these pastes 50 oz. of boiling water are run into a porcelain mortar, then 2 oz. of phosphorus which soon melt therein; 40 oz. of flour are then added whilst stirring with a wooden spatula. When the mixture is almost cold 40 oz. of molten tallow still tepid are run in and 20 oz. of sugar. This paste may be used indifferently against rodents and certain injurious insects. The *Murides*, such as *Arvicola* (field mice), *Mus musculus* (domestic mouse), *M. agrarius* (field mouse), *M. ratus* (ordinary rat), *M. decumanus* (Surmulot rat), are destroyed by the phosphorus pastes, the preparation of which is given above. Mohr adds a little glycerine which preserves them longer in the air. With this poisonous paste slices of toasted bread are coated which the rodents eat without suspicion. According to Crampe it suffices to prepare a paste of boiled flour which is cooled to 43° C. (109·4° F.) before mixing in the phosphorus; pieces of straw are then dipped into the paste and laid in the burrow or in the run of the rodents. The latter in trying to remove them or in walking on them get daubed with pieces of paste on the hair, and are poisoned by licking themselves.

Amongst the insects killed by phosphorus are: *Periplaneta orientalis* (cockroach). This insect does great damage in hothouses by gnawing orchid roots. Paste pills made from honey and phosphorus and laid on the pot of the plant attacked rapidly destroy the insect.

*Gryllotalpa vulgaris* (mole-cricket).—Elias Hugo destroys it by laying poisoned pastes of maize, starch, water, and phosphorus in the burrows and stopping up the orifices. The mole-crickets disappear in twenty-four hours.

*Formica* (ants).—To poison ants Debray introduces phosphorus paste made from molasses and phosphorus. The orifices of the nest are then stopped.

**Phosphoretted Hydrogen,** $PH_3$.—**Preparation.**—(1) By the action of phosphorus on caustic alkalies or the hydroxides of the alkaline earths in presence of water and under the influence of heat. (2) By decomposition of calcium phosphide by water alone or by hydrochloric acid.

**Properties.**—Phosphoretted hydrogen is a colourless gas with a strong smell, resembling rotten fish, inflaming at 60° C. (140° F.). It is poisonous, and acts especially by depriving the hæmoglobin of the blood of the oxygen fixed therein.

**Use.**—Phosphoretted hydrogen is recommended for combating the phylloxera. Mouillefert showed this gas to be five times more poisonous than prussic acid. An atmosphere containing 0·5 per cent. of phosphoretted hydrogen is very injurious to the phylloxeras, but the latter are not destroyed until after they have been fourteen hours in an atmosphere containing 1 per cent. of this gas. Experiments on the large scale have given variable results; those of Mouillefert, a negative one; those of Rosler, a perfect one. The former wrought thus: 20 grammes (310 grains) of phosphide were laid in three holes of 50—60 centimetres (20—24 inches) in depth, at equal distances round a stock, and then closed. The moisture and carbonic acid in the soil decomposed the calcium phosphide. Rosler, on the other hand, recommends the digging of holes around the stock, and to lay therein several layers of quicklime, on which a small piece of phosphorus is placed. The holes, filled up, are covered with water and then stopped with clay. Rosler recommends this treatment as efficacious, and without any injurious effect on the vine treated; it is done in the spring. Mouillefert ascribes the bad result of his experiments to the rapid oxidation which goes on in the soil, and to the feeble diffusion of phosphoretted hydrogen, which is less rapid than carbon disulphide.

**Arsenious Acid,** $As_2O_3$.—Arsenious acid, or arsenic, is obtained, commercially, by roasting arseniferous minerals, the arsenides, and sulpharsenides of nickel, cobalt, and iron, in capacious muffles, of refractory material, round which the flame from the fire circulates.

$$2FeAsS + 3O = 2FeS + As_2O_3.$$

The arsenious anhydride given off is led into cold, superimposed chambers, where it condenses as a white crystalline powder. It is removed by raking it out and purified by distilling it in wrought-iron vessels.

**Properties.**—White arsenic is a white or colourless, inodorous solid;

recently fused, it forms a vitreous, transparent, amorphous mass. White arsenic only dissolves at 13° C. in water, in the ratio of 1·2—1·3 per cent., whilst the vitreous acid dissolves in the ratio of 4 per cent. Its taste is at first faint, then bitter and nauseous. Arsenious acid is a violent poison for all animals, and in a dose of 1 decigramme, say 1½ grains, kills man. It is a violent escharotic of the mucous membrane, and of all the tissues in general, which it inflames, and rapidly destroys. Absorbed by the digestive channels, it gives rise to gastro-intestinal symptoms, which are often followed by paralysis. In very small doses it is a powerful stimulant, which encourages growth. This property causes it to be much used in medicine. Arsenic is as poisonous to plants as to animals. It burns the leaves. Arsenites soluble in water are the more active the greater their solubility; those which are insoluble in water consequently have no injurious action on plants.

Herbaceous plants die when they are watered with a 0·5 per cent. solution. Deciduous trees are also very sensitive to the action of arsenic. To destroy certain insects, a solution of 200 grammes in 100 litres (2 lb. per 100 gallons) were tried, but even in that proportion the arsenic is still too prejudicial to the leaves.

TABLE XVI.—*Showing Sensitiveness of Leaves of Various Fruit Trees to Solutions of Arsenious Acid of Various Strengths.*

| Name of tree. | Grammes $As_2O_3$ per 100 litres.[1] | Effect on leaves. | Name of tree. | Grammes $As_2O_3$ per 100 litres.[1] | Effect on leaves. |
|---|---|---|---|---|---|
| Apple | 30 | Browned | *Negundo aceroids* | 30 | Burnt |
| Plum | 15 | ,, | *Gleditschia triacanthus* | 24 | ,, |
| Plum | 10 | Attacked | Poplar | 15 | ,, |
| Vine | 48 | Burnt | Raspberry | 34 | ,, |

Gillette found that in a much weaker dose arsenic is still injurious, and that, in this respect, different plants are not equally sensitive.

These doses being often insufficient to kill the insects, arsenic solutions were completely abandoned, and replaced by neutral bouillies, in which the arsenic is generally in the insoluble condition, and thus in a form which does not injure the plant. Arsenious acid has also a very decided action on the spores of fungi. This action was long known and utilized to disinfect cereal grains, when, in 1856, Boussingault recommended the use of arsenite of soda for the disinfection of grain. This process was, in his opinion, the best for freeing farm crops from smut, bunt, rust, caries and ergot; it, moreover, had the advantage of protecting the grain from the ravages of injurious animals after sowing.

**Arsenic Compounds.**—White arsenic is the basis for the manufacture of all arsenical insecticides, some of which, especially the lead and calcium salts, find an extensive use. These are dealt with under separate headings. Arsenites are prepared by combining arsenious oxide with a base. Arsenates are produced by first oxidizing arsenious oxide to arsenic oxide (arsenic acid) and then combining the material with a base. Except for their water content of approximately 50 per cent., the paste arsenicals have the same general composition as the powdered arsenicals. The usual lead arsenate on the market, acid lead arsenate ($PbHAsO_4$), is well standardized and stable. Basic lead arsenate ($Pb_4PbOH(AsO_4)_3$), also well standardized and stable, is being manufactured at present only to a limited extent. Chiefly because of its low arsenic and high lead contents, basic lead arsenate is more stable and therefore less likely to burn foliage than acid lead arsenate. It possesses weaker insecticidal properties and is somewhat more stable in mixtures than acid lead arsenate. Commercial calcium arsenate (arsenate of lime), the manufacture of which is rapidly becoming standardized, contains more lime than is required to produce the tribasic form. Paris green, an old and well standardized arsenical, is less stable and contains more " soluble arsenic " than commercial arsenates of lead or lime. The following combinations of insecticides and fungicides were found to be chemically compatible : Lime–sulphur and calcium arsenate; nicotine sulphate and lead arsenate; and Bordeaux mixture with calcium arsenate, acid lead arsenate, zinc arsenite, or Paris green. The following combinations were found to be chemically incompatible : Soap solution with either calcium arsenate or acid lead arsenate; kerosene emulsion with either calcium arsenate or acid lead arsenate; and lime–sulphur with acid lead arsenate. Combined with nicotine sulphate, calcium arsenate always produces free nicotine, and unless a decided excess of free lime is present soluble arsenic is produced. The combination of sodium arsenate with Bordeaux mixture as used in experiments of the U.S. Bureau of Agriculture gave no soluble arsenic.

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[1] Parts by weight in 100,000 parts by volume.

**Bordeaux-arsenic Dust.**—The most common Bordeaux-arsenic dust is blue when moistened with water. A green dust is made from burnt lime, copper sulphate and white arsenic, while a brown dust is made from burnt lime, copper sulphate and arsenic acid. In the control of biting insects all three dusts gave very similar results, being all highly effective against leaf-eating insects such as tent caterpillars (*Malacosoma*), the green dust, perhaps, proving somewhat superior to the others.

**Use.**—The French Ordinance of 1846, Article 10, " The sale and use of arsenic and its compounds are interdicted for the pickling of grain, the embalming of corpses, and the destruction of insects," has prevented its use in France, but in other countries the valuable properties of this product have earned for it numerous applications. The first trials were made in America in 1867, when Markham used arsenic to combat an insect very deadly to the potato, the *Leptinotarsa decemlineata*[1] or Doryphor of Colorado (the Colorado beetle). The use of arsenic became general in 1871, but especially in the form of neutral bouillies, with an emerald green or Scheele's green basis, London purple or arsenite of lime, or in admixture with different anti-cryptogamic salts. Gillette also recommended, in the form of powder, mixed with much flour. In this form it has been recognized as less injurious to the leaves than in solution, and is thus recommended every time that spraying cannot be adopted. To-day white arsenic is hardly used except to poison the pastes for the following insects: *Agriotes lineatus* or *Elater segetis*, L. (wire-worm), injurious to cereals; *Agriotes* or *Elater sputator*, L. (spitting click beetle), injurious to lettuce; *Agriotes* or *Elater obscurus*, L. (dusky click beetle), injurious to carrots. It is very difficult to get at the larvæ, as they live hidden. Comstock recommends to destroy them by pastes poisoned by arsenic. For this purpose small bundles of lucerne are prepared towards July, of which the larvæ are very fond; they are dipped in a 1 per cent. solution of arsenious acid, they are then placed in the infected fields, taking care to cover them with flower-pots so as to keep the lucerne moist which should always appear as if fresh cut.

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[1] LEPTINOTARSA DECEMLINEATA (the Colorado beetle).—Deep yellow Coleoptera, closely allied to the chrysomelides; 1 centimetre in length with five black longitudinal lines on each elytrum. This insect does great damage to potato fields in America. It gnaws the leaves as larva as well as in the perfect state, and produces abortion of the tubers. Energetic methods are adopted to prevent it being imported into France [and Great Britain].

In the Virgin Islands the larvæ of *Pieris* (*Pontia*) *monuste* (southern cabbage butterfly) were successfully controlled by the application of a dust of 1½ parts of a commercial preparation of arsenic (containing 30 per cent. of arsenic oxide), 1½ parts of lime and 7 parts of finely ground sulphur.

*Grasshoppers.*—For making poisoned bran mash for grasshoppers in Minnesota, the formula recommended are 100 lb. coarse wheat bran (free from shorts), 5 lb. crude white arsenic, 5 lb. salt, 3 oz. amyl acetate (technical grade), 2 U.S. gals. molasses (low grade), and 10 or 12 U.S. gals. water.

*Gryllotalpa vulgaris* (mole-cricket).—To poison this insect Lehmann spreads in the spots frequented by it preparations made thus: thyme, sweet marjoram, sweet basil, with ground arsenic, earth, or sand. The mole-crickets, very fond of these seeds, come to eat them and are poisoned.

*Acrydium migratorium* (Criquet migrateur); *Acrydium peregrinum* (Criquet pelerin).—Chemicals are only rarely used to combat these locusts; battues and Cypriot's apparatus are preferred. However, Coquillot recommends the use of poisonous preparations. One lb. of sugar is dissolved in enough water to form a syrup, there is then stirred in 1 lb. of arsenic and 6 lb. of bran. This paste is divided into pieces the size of a nut and then laid in front of the line of invasion of the locusts at the distance of a yard and in several parallel rows.

*Agrotis segetum*, W. V. (the common dart moth); *Agrotis exclamationis* (the heart and dart moth).—Coquillot recommends bunches of lucerne, steeped in a 1 per cent. solution of arsenic, or the preparation already prescribed to destroy locusts. The preparation is placed round the stocks of the vines; the grub, seeking its shelter in the morning on the vine, grazes the arsenic of the preparation and is poisoned by contact, for this product kills the insects that touch it as well as those that absorb it through the digestive channels.

*Kermes.*—It is asserted that these parasites do not resist a 1 to 3 per cent. solution of arsenic.

*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—Arsenious acid was proposed like other substances at the moment of the phylloxeric invasion. The insecticide properties of this product being known, it was hoped to be able to destroy this formidable insect by watering the soil round the stocks with a dilute solution of this poison. The phylloxera infected vines, after having been stripped within a radius of 10 inches round the root, were each treated with 25 grammes of arsenic dissolved in 10 litres of water. [Dissolve 2½ lb. arsenic in 100 gallons water and give each vine 2⅕ gallons.] The adult phylloxera were found dead, but the young ones were quite robust. As soon as the diffusive action of the soil had rendered the arsenic powerless, the phylloxera multiplied once more. Other trials showed that this dose is quite insufficient to destroy the phylloxera of the vine. Vines so infected placed in pots containing 4 litres of earth received 1·5 grammes (23 grains) of arsenic in 100 grammes (3½ oz.) of water. This, though a considerable dose, did not free the vine from its parasites. It corresponded to 375 grammes of arsenic per cubic metre of soil, and is not withstood by the vine, which can stand a ¼ per cent. solution, but a ⅓ per cent. affects it. Arsenic has not therefore been judged capable of being taken into account for the destruction of the phylloxera.

*Rodents* (mice, rats, field mice, moles).—Arsenic is the poison most often used to destroy rats. There are different methods of utilizing it: (1) Boil wheat in water saturated with arsenic; boiling must not be too prolonged, as the grains must remain hard. Place some of the grains, after wiping them, in each hole. To destroy the field mouse it is better to operate in winter, when the animal is famished. (2) Mix 100 grammes of arsenic (3½ oz.) with 1 kilogramme of tallow (say 2¼ lb.), 4 grammes (say ⅛ oz.) anise, and 10 grammes (say ⅓ oz.) lampblack. The paste is spread on very thin slices of toasted bread. (3) Mix 4½ oz. flour with 1 oz. of arsenic and place a little of the powder in a drain pipe, about 1⅓ inch in diameter; place this pipe near mole holes. This method keeps the poison beyond the reach of game and dogs. These pipes can also be used for poisoned grain. (4) Cut a celery root in two parts, make a cavity in each piece, and fill it with arsenic, then stick the two pieces together by a glue without smell. Thus, after removing the point of one of these roots a conical hole is made in it, arsenic placed in the opening so made, and closed by the piece removed, which forms a natural plug. Place the celery so prepared in the nests. Complete success will be obtained if precaution be taken to accustom the rodents to this preparation by giving them first non-poisoned celery.

**Arsenic Acid,** $As_2O_5$.—**Preparation.**—By oxidizing arsenious acid by nitric acid.

**Properties.**—Arsenic anhydride is a white solid. It dissolves slowly in water. It is a more violent and more rapid poison than arsenious acid.

**Use.**—Arsenic acid has been proposed for the disinfection of seed-corn. A powder is prepared with 9 parts of lime and 1 part of arsenic acid, with which the corn kept moist is sprinkled in the proportion of 3⅓ lb. per 2¾ bushels of grain. After twenty-four hours the seeds were dried and sown.

# CHAPTER VI

AMMONIA—AMMONIUM SULPHIDE—AMMONIUM SULPHATE—AMMONIUM CARBONATE—SODIUM HYPOSULPHITE—SODIUM SULPHATE—SODIUM CHLORIDE (COMMON SALT)—CAUSTIC SODA—SODIUM NITRATE (CHILI SALTPETRE)—ARSENITE OF SODA—BORAX—SODIUM CARBONATE—SODIUM FLUORSILICATE

**Ammonia,** $NH_3$.—**Preparation.**—By distilling ammoniacal gas liquor with lime; also synthetically by the Haber and other processes.

**Properties.**—Ammonia is a colourless gas with a pungent smell, which irritates the mucous membranes, and an acrid taste. Ammonia is one of the nutritive substances of the plant, and its presence in the air greatly stimulates the growth. The dose injurious to plants is about 1000 times greater than the normal dose. Some plants are more sensitive than others. Whilst 243 milligrammes of ammonia per cubic metre of air had no bad effect on oaks, even if they remained an hour in that atmosphere, 70—86 milligrammes caused a pathological condition on plum-trees and cherry-trees. A dose of 32—36 milligrammes of ammonia per cubic metre has no caustic action on the most sensitive of vegetables. The symptoms of burning by ammonia are the following: The leaves of the oak blacken; those of cherry-trees and plum-trees become brown; haricots blacken; and cereals lose their colour and become quite pale. Young buds are much more sensitive than old leaves. A 0·003—0·005 per cent. solution has no action on the protoplasma of maize, haricots, tomatoes, and strawberry plants; more concentrated solutions increase the movements of the protoplasma.

The seeds of *Phaseolus multiflora* germinate in nine days in an atmosphere containing 0·003—0·004 per cent. of ammonia; likewise the seeds of *Vicia faba*, when the ambient air contains 0·0031 per cent. of this gas. In an atmosphere containing 0·005 per cent. of ammonia leguminous seeds cannot germinate, and a 0·0083 per cent. solution exercises an unfavourable action on young maize, owing to its diminished growth.

**Use.**—The causticity of ammonia being known, it is evident that care must be taken not to bring it in contact with plants. Ammonia enters into the composition of certain anticryptogamic bouillies, and chiefly *eau celeste* used to kill mildew. The good effects of this preparation are indisputable; but they can only be obtained by working with an absolutely neutral solution, a point which does not receive in the majority of cases the serious supervision which it requires. It follows that mishaps occur, which should not be produced with a substance possessing all the properties that can be desired. Pure ammonia has few applications in agriculture. However, gas liquor, which is cheap, is in general use. These ammoniacal liquors kill mosses in meadows and impart fresh vigour to grain crops. But in the condition in which they are bought these liquors are too concentrated, and might kill graminaceous crops. They must be reduced by an equal quantity of ordinary water, and only 4000 litres of this mixture spread per hectare (352 gallons per acre). The following diseases are combated by ammoniacal treatment:—

*Heterodera Schachtii*, Schmidt (nematode of the beet).—Willot has published very satisfactory results which he has obtained by the use of ammoniacal liquors. The infested beet fields, producing, on an average, 4 tons of beets per hectare, say 1·6 tons per acre, yielded 37 tons per hectare, say 14·4 tons per acre. In Willot's patent the nematodes succumb to the alkaline action of gas liquors, provided they contain 5 per cent. of ammonia. The results obtained by others have not been so favourable. Hollrung remarks that beet seed was not capable of springing up in a soil treated with ammoniacal liquor. To avoid this drawback Willot follows up his treatment by spraying with ordinary water. Be that as it may, this treatment cannot be so efficacious as that due to Aimé Girard, which consists in using a strong dose of carbon disulphide, and which ought always to be preferred.

*Jassus sexnotatus*[1] (grain grasshopper).—Steglich recommends ammoniacal liquor of gasworks, in which 2 per cent. of soft soap is dissolved, the whole diluted with an equal bulk of water, to get rid of this pest. Sorauer eulogizes the good effects of this treatment, and recommends spraying with a solution made in the ratio of 30 lb. of soft soap and 3 gallons of commercial ammonia in 100 gallons of water.

**Ammonium Sulphide,** $(NH_4)_2S$.—**Preparation.**—Ammonia forms, when combined with a semi-molecule of sulphuretted hydrogen, hydrosulphide of ammonia or ammonium sulphide.

**Properties.**—Ammonium sulphide is in the form of yellow crystals which are very soluble in water. It is usually obtained as a yellow liquid which has a very strong smell of rotten eggs.

**Use.**—*Dematophora necatrix*, Hartig (root rot).—Dufour tried to replace carbon disulphide by this substance, but the results obtained were not perceptible.

*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—Mouillefert found that the phylloxera dies in twenty-four hours in an atmosphere containing 1 per cent. of ammonium sulphide. Used in small dose on a vine in pot where the whole soil could be impregnated with this substance, the result was satisfactory, but on the large scale diffusion is not so perfect, and the result was always incomplete in spite of the toxicity of the two gases which form this salt, ammonia and hydrogen sulphide. Mouillefert experimented thus: The stocks, stripped to 30—35 centimetres (12—14 inches), were watered with 400 cubic centimetres of the liquid sulphide, then with 10 litres of water; after the liquid was absorbed the earth was put back round the stock. On roots 50—60 centimetres (20—24 inches) deep the effect was, so to speak, *nil*, and it was even observed that the phylloxeras had not been entirely destroyed on the upper roots. According to Couvy and Rohart, this bad result was due to the ammonium sulphide rapidly decomposing in the soil to form inert combinations such as ammonium sulphate.

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[1] JASSUS SEXNOTATUS, CICADELLA SEXNOTATA (Cicadella of oats, Cicadella of cereals).—Yellow grasshopper, with brown spots, 3 millimetres long. They suck the leaves of the oats which turn yellow and wither.

*Cochylis Ambignella*, Hubn. (cochylis of the vine).—Dufour recommends against the grub of this butterfly a solution of 3 per cent. of ammonium sulphide and 3 per cent. of soft soap, which he regards as being more efficacious than carbon disulphide.

An ammonium polysulphide wash is recommended by the British Ministry of Agriculture for destroying American Gooseberry Mildew (*Sphærotheca mors-uvæ*, Berk.). The solution is diluted to a strength of 0·11 per cent. of polysulphide and used with 0·5 per cent. of soft soap (5 lb. of soft soap to 100 gallons of wash).

**Ammonium Sulphate** $(NH_4)_2SO_4$.—Sulphate of ammonia is manufactured commercially by distilling the ammoniacal liquor of gasworks and is also a by-product of blast furnaces and of oil-shale distillation. The volatile portions are collected in dilute sulphuric acid, the liquors obtained are concentrated in lead tanks, where the sulphate of ammonia crystallizes in prisms.

**Properties.**—Ammonium sulphate forms anhydrous permanent prisms. It dissolves in 2 parts of cold and 1 part of boiling water.

**Uses.**—As an ammoniacal manure.

*Heliophobus popularis.*—Amongst the insecticides used to destroy the grub of this Lepidoptera, which causes such damage to meadows, Marchand found that only a 10 per cent. solution of ammonium sulphate in purin gave appreciable results.

*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—According to Rosler's experiments on the phylloxera, with the most diverse substances, ammonia had on these plant-lice as energetic an effect as carbon disulphide and sulphuretted hydrogen, but that it had not such a poisonous effect on the plant as the two latter gases. To generate the ammonia gas in the zone invaded by the louse, Rosler recommends piercing holes with the injector round the vine, and filling them either with alternate layers of newly slaked lime and ammonium sulphate, and spray afterwards with water, or with lime alone, and then spray with a solution of sulphate of ammonia. The holes are then plugged with clay or wooden plugs. The ammonia gas generated by the mixture of these substances reaches the phylloxera, and infallibly kills it.

Mouillefert determined that if the phylloxera be sensitive to ammonia it is difficult on the large scale to destroy it with ammoniacal liquor. A phylloxera-infested root dipped for three minutes in ordinary ammonia, or exposed for an hour to the vapours of 5 cubic centimetres of this substance in a 2-litre bottle was freed from all its parasites, but these experiments repeated on a phylloxera-infested vine in pot gave no good results. For that purpose 10 cubic centimetres of ammonia were poured into two holes which were immediately plugged. The beards of the root in existence before the experiment were destroyed and the swellings on the large roots still bore numerous parasites. Ammoniacal liquor, according to this experiment, is not, therefore, capable of destroying the phylloxera without imparting grave injuries to the plant. In fact, 20 cubic centimetres of this liquor employed in the same conditions on a healthy vine burnt the leaves, and 40 centimetres killed them. Ammonia used as vapour does not appear to have the injurious action of ammoniacal liquor on plants. Ammonium sulphate used according to Rosler's indications, may thus have as great an action on the phylloxeras as it has on the vine, by imparting new vigour to it in virtue of its nutritive properties.

**Ammonium Carbonate** $(NH_4)_2CO_3$.—**Preparation.**—By heating in a cast-iron retort an intimate mixture of equal weights of ammonium sulphate and chalk. The volatile salt is condensed in a receiver. Another method is by heating ammonium hydroxide with ammonium bicarbonate.

**Properties.**—Ammonium carbonate is a white fibrous mass with a caustic taste and exhaling ammoniacal odour. In contact with air it loses a part of its ammonia and is converted into a more stable bicarbonate. Solutions of ammonium carbonate are completely dissociated into ammonia and carbonic acid when heated.

**Use.**—Hitchcock and Carleton have observed that a 1 per cent. solution of ammonium carbonate stopped the growth of the uredospores of *Puccinia coronata*, Corda, after seventeen hours' action.

*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—The effects of ammoniacal manure, such as ammonium carbonate, which stable manure contains in notable quantities, have always been successful on phylloxera-infested vines. Rosler ascribes this to the ready dissociation of this salt into ammonia —especially poisonous to the phylloxera —and carbonic acid. So as to render it still more active, he advises the manure containing the ammonium carbonate to be spread in the spring, because the young generations of phylloxera are much more sensitive than the adults. Mouillefert is of another opinion. According to his experiments a solution at the rate of 2 lb. of this salt in 25 gallons of water with which he watered a phylloxera-infested vine was incapable of killing the phylloxera. He concluded that ammoniacal salts only acted as fortifiers of the plant.

**Sodium Hyposulphite,** $Na_2S_2O_3,5H_2O$.—**Preparation.**—Sulphites boiled in presence of sulphur are converted into hyposulphites. To accomplish this, a solution of sulphite of soda is boiled with excess of sulphur until saturated; it is filtered and cooled. Large crystals of sodium hyposulphite form. Commercially this salt is prepared by the action of sulphurous acid on calcium sulphide (alkali waste). The hyposulphite of lime formed is converted by sodium sulphate into sulphate of lime and hyposulphite of soda.

**Properties.**—Hyposulphite of soda is a colourless salt, permanent in air, with a bitter taste and very soluble in water. It is less stable in solution than in crystals; even in the absence of air it is decomposed into sulphite of soda and free sulphur which is deposited. In contact with acids the hyposulphite is decomposed into fine sulphur and sulphurous acid:—

$$Na_2S_2O_3 + 2HCl = 2NaCl + H_2O + SO_2 + S.$$

Heated out of contact with air it splits up into sodium pentasulphide and sodium sulphate. The use of sodium sulphite has been recommended in medicine, especially against itch. Rubbing with a solution of hyposulphite of soda is followed by washing with dilute hydrochloric acid. The sulphurous acid disengaged and the sulphur precipitated in the pores of the skin make the sulphite a very efficacious agent in the destruction of this *Acarus*.

**Action on Plants.**—The hyposulphite acts like the sulphite of soda and sulphurous acid. Absorbed by the leaves of plants it is there converted into sulphuric acid and burns the leaves. The experiments therefore to replace sulphur by this salt which, so to speak, contains dissolved sulphur have been abortive because it burns the leaves, and the more so the greater the heat. Kaserer observes that it suffices to use a solution of hyposulphite rendered alkaline by milk of lime to obviate this drawback.

**Action on Fungi.**—Sulphur in hyposulphite of soda preserves its anticryptogamic properties and imparts them to it. Like sulphur hyposulphite of soda has been recognized as capable of killing all fungi, the mycelium of which crawls on the surface of the plant.

*Puccinia coronata*, Cord. (coronated rust of oats).—Hitchcock and Carleton examined the action of solutions of hyposulphite on the uredospores of this rust and found that a 1 per cent. solution has no injurious action thereon, but it exerts a retarding action on the germination and a diminution thereof on the seed steeped therein for twenty-six hours.

*Uncinula americana*, How. (oidium of the vine).—Pauly examined the action on oidium of a double hyposulphite of soda and silver. After a microscopical examination he observed the great alteration undergone by the mycelium in contact with a solution containing 0·1 to 0·2 per cent. of this salt, and concluded that the use of this salt as a curative agent would give good results. However this salt has been abandoned in the treatment of the vine because it burned the leaves especially during great heat, and that much more so than the sublimed sulphur which it was to replace.

By adding 300 grammes of hyposulphite of soda to a 1·5 per cent. bouillie bordelaise, Kaserer obtained by three sprayings in a year complete success in treating oidium without the treatment being followed by the burning of the leaves. Solutions of hyposulphite to which milk of lime was added have been found more energetic than sulphur.

*Sphærotheca pannosa* (mildew of the rose).—Vesque proposes hyposulphite of soda to destroy mildew of the rose.

*Guignardia Bidwelli*, Viala et Ravay (black rot of vine).—Pauly remarks that the double salt, hyposulphite of soda and silver, is capable of arresting the progress of the black rot in full evolution; used in a 1 per cent. solution its effect on the spores and the mycelium is most conclusive. This product has therefore been used to destroy this disease by making three sprayings per annum on the attacked vines. This treatment, which burned the leaves, has not been the success anticipated.

Crouzel's anticryptogamic which contains both calcium polysulphide and a little naphthaline, and 0·2 per cent. of hyposulphite of soda is recommended to combat the cryptogamic diseases of the vine, and particularly the black rot and the oidium. Spraying should alternate with five or six days' interval with those made from copper preparations.

**Sodium Sulphate,** $Na_2SO_4$.—**Preparation.**—By decomposing sodium chloride by sulphuric acid:—

$$2NaCl + H_2SO_4 = Na_2SO_4 + 2HCl.$$

**Properties.**—Crystallized sodium sulphate or Glauber's salt contains 10 molecules of water of crystallization. Heated, these crystals melt in their water of crystallization and lose it by igneous fusion. Anhydrous sodium sulphate, a white amorphous powder, is formed. Sodium sulphate reaches its maximum solubility in water at 33° C. It is a neutral body which has no action on plants except when highly concentrated. Seeds, however, do not stand without injury prolonged immersion in a bath of 2 per cent. of sulphate of soda.

**Use.**—Mathieu de Dombasle discovered the injurious action of this salt on the spores of *smut* and *bunt,* and proposed it to replace common salt then in use to disinfect grain by sodium sulphate. The process in use up to then had many drawbacks. It consisted in macerating the grain in a mixture of lime and common salt for twenty-four hours, and only gave incomplete results. The use of the "Absolute Preservative of Mathieu de Dombasle" was a real progress from all points of view; it shortened the long immersion and gave a better result without injuring the grain treated. *Process.*—Dissolve 8 kilogrammes (17·6 lb.) of sodium sulphate in 100 litres (22 gallons) of water. Spread on the water-tight floor (of a ground floor) 1 hectolitre ($2\frac{3}{4}$ bushels) of the grain to be disinfected and water the heap with this solution, stirring with the shovel until all the grains are well moistened. Then spread 2 kilogrammes (4·4 lb.) of lime recently slaked over the moistened grain, and stir the heap until all the grains are covered with a layer of lime. Hequet d'Herval declares that the success of this treatment is complete, and Loverdo regards this process as that which gives the best result, after Kuhn's blue vitriol disinfection process. Sulphate of soda is, moreover, less injurious to the grain than blue vitriol. Comes has slightly modified this treatment and advises that the spraying of the heap of grain be replaced by immersion in a solution of sulphate of soda. It suffices to immerse the seeds in a concentrated solution of sulphate of soda so that they are completely covered, then add milk of lime and stir for two hours, then spread the grain out to dry. G. Arieti estimates that sulphate of soda has a more injurious action on the spores of *Tilletia* (bunt) than sulphate of potash. He advises not to exceed a 2 per cent. solution for the sake of the vitality of the grain, this quantity being quite sufficient to fulfil the object of sulphating (pickling).

**Sodium Chloride (Common Salt),** NaCl.—**Occurrence.**—Common salt is found crystallized in thick beds in certain countries and is dissolved in water, filtered and crystallized. It also occurs in solution in sea-water and brine springs, from which it is evaporated.

**Properties.**—Salt is met with as anhydrous crystals. The degree of solubility of the salt in water varies little, whatever be the temperature; 100 grammes of water at 18° C. dissolve 36 grammes of salt, and at 100° C. 40 grammes. Its use is necessary in the nutrition of the animal; administered in too high a dose, it cannot be eliminated by the skin, the kidneys, and the intestines, and remaining accumulated in the blood it may coagulate the albumen.

**Rôle of Common Salt.**—Sodium chloride or its elements, with few exceptions, are present in almost all plants. A feeble dose of common salt may thus act as a manure for plants, but a strong dose may be so injurious as to kill them. If the quantity of salt used exceeds a certain dose, it stops germination of the seed and the growth of plants. Dieterich proved that big doses of salt completely paralyse the first phases of plant life, and prevent the development of the plant. But all plants and all seeds do not stand the action of salt to the same extent. As a result of some laboratory experiments, it is recognized that barley stands stronger doses of salt than tares, and oleaginous seeds resist salt better than other seeds.

**Common Salt as Manure.**—To a greater extent than potassium, the sodium necessary to the plant exists in all soils in sufficient quantity. Practice has, however, shown that the application of common salt to a soil rich in sodium is always followed by good results, provided always that a certain dose is not exceeded. In these conditions it is evident that it cannot act as (plant) food, and its rôle must be regarded from another point of view, and possibly the following. According to Braconnot, one of the first effects of salt added to a soil is to keep it moist. This property, which the salt owes to its affinity for water, is in a high degree favourable to the transport of the elements assimilated in the plant. Liebig and others agree in attributing to common salt the rôle of a solvent of phosphate of lime. Liebig found that a solution of 1 kilogramme (2·2 lb.) of common salt in 500 litres (110 gallons) of water dissolves 15 grammes, say ½ oz., of phosphate of lime. The good effects of salt may be confirmed by spreading a small quantity on the land. In big doses it is, on the contrary, antiseptic and prevents the putrefaction of organic matter in the soil, and consequently the formation of nitrates. The nitrification of organic matter goes on slowly in cold weather; salt, therefore, has more action in southern countries than in northern countries. For the action of salt on arable land to be complete heat and moisture must be intermittent. In dry years salt may be injurious, because it then acts as a caustic, and corrodes the plant. Plants on the sea-coast are watered naturally by the salt water of the sea. Where the desiccating action of the wind cannot wither up plants sheltered behind walls, hedges, or forests, vegetation becomes luxuriant. It is otherwise quite on the seashore, the excess of salt, especially magnesium chloride, being as injurious to plants as the drying wind. Barren zones are thus to be found along the shore. The experiments of Lecocq have shown that it requires 150—200 kilogrammes (330—440 lb.) of common salt per hectare, say 132—176 lb. per acre, as a manure for lucerne, 250—300 kilogrammes (550—660 lb., say 220—264 lb. per acre) for flax and wheat, and 264 lb. per acre for barley. Others have confirmed these figures and give 264—440 lb. per acre as a suitable dose.

**Use against Injurious Plants.**—Salt in excess is injurious, and certain plants stand it with difficulty. Wendler found common salt an excellent means of destroying charlock. Waste salt may be used with good effect as a weed-killer on garden paths. A strong dose of salt has a corrosive action on delicate plants; thus mosses and horsetails which invade meadows succumb long before the gramineæ. Used on meadows and fields in a dose to kill moss, it only retards the growth of the gramineæ; applied on corn fields, it keeps the stem shorter, imparts a certain rigidity and prevents laying. Watering paths with a 10 per cent. solution is the method used to destroy weeds; unfortunately it only destroys them momentarily and imperfectly because they spring up again as soon as rain comes to wipe out the treatment. It is more effective when applied in a dry state. Top-dressings of salt at the rate of 5 to 7 cwt. per acre have, in some cases, proved very effective against the weed Yellow Rattle (*Rhinanthus Crista-Galli*, L.). There is a risk, however, of this treatment seriously damaging grass or clover.

**Use of Common Salt against the Diseases of Plants.**—*Bacterian diseases of the potato, scab, crevices*, etc.—Becquerel experimented with common salt on the diseases of the potato. This product, in big doses, being an antiseptic, it might, therefore, prevent the extension of these diseases. The potatoes were planted in winter, and to prevent the frost getting at them the tubers were planted at a depth of 15 inches, with 10 grammes of salt, and others without any saline manure. In the salted ground the potatoes could be harvested two months before the normal time, and whilst on the ordinary soil there were 10 per cent. of diseased potatoes, on the soils supplied with salt all the tubers were sound. According to Peters there is even an increased yield, but on the other hand a diminution in the total amount of starch. The same result occurs, therefore, as with the beet; the improvement brought to bear on this crop by common salt and the increased yield are rather illusory, since the weight of the beet increases whilst that of the sugar diminishes.

*Rust of Cereals.*—Solutions of common salt were tried to combat this disease on the adult plants. Feburier and Phillipar obtained good results by spreading either salt or a mixture of salt and lime on the crop, but this improvement has been disputed by Loverdo.

**Use in the Destruction of Insects.**—Salt is not an insecticide, but its presence in the soil sometimes renders a sojourn there impossible or disagreeable to certain insects.

*Agriotes lineatus*, L. (wire-worm).—The larvæ of this insect have been combated by spreading a strong dose of salt on the fields. Comstock and Slingerland found that by mixing 10 tons of salt per hectare (4 tons per acre) with 10 centimetres (4 inches) of the arable surface soil these larvæ died; with only 7½ tons per hectare (3 tons per acre), the effects were imperceptible. Unfortunately to obtain good results such large doses of common salt must be used that growth cannot take place normally; hence it has been advised to apply salt during the bare fallow, as the latter is incapable by itself of diminishing the number of polyphagous larvæ.

*Pieris* (white cabbage butterfly).—The grubs of the *Pierides*, which ravage cabbages, may be destroyed by watering the latter with a solution containing 250 grammes of salt and 250 grammes of tobacco juice in 14 litres of water, say 1 lb. of salt and 1 lb. of tobacco juice in 5—6 gallons of water.

Salt has been used to kill plant lice but is useless against Phylloxera.

*Schizoneura lanigera*, Hausm. (woolly aphis).—Krafft recommends the following emulsion, which yields a satisfactory result: Petrol 800 cubic centimetres, salt water, 25 per cent., 200 cubic centimetres.

*Aspidiotus perniciosus*, Comst. (the San José louse).—In California a mixture of lime, sulphur, and salt is employed against this insect, but this preparation has been abandoned in the Eastern States owing to certain failures, and better results got by the use of whale-oil soap-emulsions.

**Caustic Soda,** (NaOH).—For a winter wash for fruit trees the British Ministry of Agriculture recommends 2 lb. of powdered caustic soda in 10 gallons of water. The soda, of 98 per cent. purity, is dissolved first in a little water and then diluted to the proper strength. The face and hands should be protected during use. Another winter wash (1 per cent. solution) which, according to the British Ministry of Agriculture, has proved useful in preventing severe attacks of wither-tip and brown rot (*Monilia cinerea*) in plums and cherries is made from: caustic soda, 1 lb., soft soap, 1 lb., water, 10 gallons.

**Nitrate of Soda,** $NaNO_3$.—**Occurrence.**—Nitrate of soda or Chili saltpetre forms thick beds, which extend on the surface of the soil under a thin bed of clay.

**Properties.**—The crystals of nitrate of soda are anhydrous, permanent in dry air, but deliquescent in moist air. They are much more soluble in hot water than in cold water; 100 grammes of water dissolve 80 grammes of nitrate at 10° C. and 217 grammes at 119° C.

**Action on Plants.**—Nitrate of soda is a plant food, but like most salts in strong solution, it is injurious to certain plants. Steglich submitted the most diverse plants to a 30 per cent. solution and to one of 15 per cent. with the following results:—

TABLE XVII.—*Showing the Effect of a 30 per cent. Solution A and of a 15 per cent. Solution B of Nitrate of Soda on Different Plants.*

| Plants. | A. | B. | Plants. | A. | B. |
|---|---|---|---|---|---|
| Grain . | Fleeting 5–7 days | Nil | Charlock . | Very sensitive | Very sensitive |
| Beets . | Nil | ,, | Sorrel . | Nil | Nil |
| Potatoes | Deadly | Deadly | Knot grass | ,, | ,, |
| Trefoil | Slight | Nil | Horsetail . | ,, | ,, |
| Lupin | Deadly | Deadly | Peas . . | ,, | ,, |
| Flax . | ,, | ,, | Mustard . | Deadly | Deadly |

The property of nitrate of soda of killing certain plants without killing others has been utilized in farming to free fields invaded by certain adventitious plants. Duserre recommends the use of a 20 per cent. solution to destroy mustard in cornfields. It is preferable not to use nitrate of soda alone, but mixed with a little blue vitriol. The young mustard dies after watering with a solution containing 10 per cent. of nitrate of soda and 2 per cent. of blue vitriol. Older mustard requires a solution containing 3 per cent. of blue vitriol and up to 20 per cent. of nitrate of soda; 10 hectolitres (22 gallons) of this solution are required per hectare ($2\frac{1}{2}$ acres). The use of nitrate of soda has, in this case, the advantage of serving as a manure to the grain crops, and by stimulating their growth renders them more apt to struggle against parasites. However, Nijpels believes that nitrate of soda, as the sole manure, encourages the development of the rust of cereals.

**Action on Fungi.**—Nitrate of soda should, logically, act like nitrate of potash on the spores of fungi. The latter salt has been studied in a very complete manner by Wuthrich.

**Action on Insects.**—Smith regards a 4 per cent. solution of nitrate of soda as a good insecticide. Concentrated solutions of nitrate of soda spread on the land are injurious, according to Miss Ormerod, to the larvæ of the *Tipula;* according to Taschenberg, to the larvæ of the *Elaterides;* and according to Weiss, to *Nematodes*, and particularly to the *Tylenchus devastatrix*, Kuhn (eelworms of wheat), which cause the disease known as the *Niel du Froment.*

**Arsenite of Soda,** $Na_2HAsO_3$.—**Preparation.**—By boiling 1 part of arsenious acid with 2 parts of soda ash.

**Properties.**—Arsenite of soda is much more soluble in water than white arsenic and consequently much more poisonous to plants. In the composition of arsenical bouillies its formation must be guarded against, or its effects neutralized by the addition of lime.

**Use.**—The soluble arsenites, such as the salts of potassium, ammonium, as well as the soda salt, have been serviceable owing to their great solubility and their immediate action on insects and injurious animals. But this use is, perforce, limited, and it can only be used to poison preparations to be eaten by insects and rodents.

*Note by Translator,* re *Arsenite of Soda.*—This substance is made a speciality of by at least one firm in Great Britain who sell it in a more or less concentrated state of solution. Several accidents have occurred from the solution having been drunk inadvertently, and some deaths occurred through leakage of a cask on to sugar casks during transit. To prevent such occurrence and render them more difficult the protective coloration of arsenical weed-killers is recommended. While the revision of this work was in progress the Railway Clearing House was informed that the Council of the Pharmaceutical Society had directed further investigations to be made with regard to the possibilities of potassium bichromate as a colouring agent for liquid weed-killers. The Railway Clearing House wrote forwarding a copy of a communication which had been sent to manufacturers of liquid arsenical weed-killers, etc. This stated that, as the result of further experiments which had been made by the railway companies' chemists with respect to the colouring of liquid arsenical weed-killers, it had been found that of the dyes tested the one most generally satisfactory was disulphine blue V, obtainable from the British Dyestuffs Corporation, Ltd. The matter had been independently the subject of investigation by the Pharmaceutical Society, and it would appear that of the dyes tried by them the same dye proved to be the best. The proportion in which the dye was added was 1 oz. to 10 gallons. The railway companies thought the manufacturers would be interested to know this, and added: "If you find any blue dye which shows improvement in permanence and quality over disulphine blue V, the companies would esteem it a favour if you would be good enough to call their attention to it."

A mixture of molasses and sodium arsenite for poisoning the olive fly (*Dacus oleæ*), recommended by Prof. A. Berlese, has a content of over 90 per cent. of molasses of consistency 1·41, in the proportion of 40—45 of sugar to 2·5 of sodium arsenite. The mixture only requires dilution with 9 parts of water, and about 10 oz. of spray is required per tree for one application. Against grasshoppers in Wisconsin the following arsenical bait had advantages: 100 lb. sawdust, 1 U.S. qt. sodium arsenite, 5 lb. salt, 1 U.S. gal. black strap molasses, and 10 U.S. gals. water, the quantity per acre being 10 lb.

**Preparations to Kill Locusts.**—In the British Colonies they prevent the migration of locusts by placing in their way bunches of fodder, herbs, or maize stems, steeped in a solution containing per hectolitre 60 grammes of arsenious acid, 60 grammes of caustic soda, and 10 kilogrammes of white sugar or molasses [or 60 oz. (wt.) of arsenious acid, 60 oz. of caustic soda by weight, and 1000 oz. of sugar (wt.) in 100,000 fluid ounces of water]. Drying is prevented by covering the bait with a board or a stone. This bait may be used for other insects.

A leaflet issued by the Rhodesian Department of Agriculture concerning the destruction of locusts by means of sodium arsenite sprays, recommends, for young hoppers (within two weeks of hatching), 3½ oz. (by weight) of dry sodium arsenite or 3 fluid oz. of concentrated solution to 4 gallons. For older hoppers the strength may be slightly increased but should never exceed 4½ oz. by weight or 4 fluid oz. to 4 gallons. The dry sodium arsenite should be dissolved by heating in a little water over a fire, and then the rest of the water should be added. For extensive operations 11 lb. of the dry sodium arsenite can be boiled in 1 gallon of water and 3 fluid oz. of this solution used in 4 gallons of water for spraying. When dry sodium arsenite is used, care should be taken that it has entirely dissolved in the vessel before use. In Russia poisoned baits (40 lb. of bran or sawdust, 2½—5 lb. of sodium arsenate, 4 gallons of water) have been tried, with excellent results.

Russian experiments for the control of locusts showed that finely-powdered sodium arsenate applied to rye at the rate of one part by weight to 20 parts of chalk does not injure the plants. The locusts would only feed on the treated plants during the first twenty-four hours, after which symptoms of poisoning were evident. By the fifth day, 96 per cent. were dead, and none survived longer than the sixth day. In a popular bulletin on grasshoppers, the recommendations for control are poisoned baits consisting of 40 lb. sawdust or dry horse dung, 1½ lb. sodium arsenate or Paris green, and 3 gals. hot water.

**Arsenite of Soda as a Weed-killer.**—A first-class weed-killer could be made by dissolving arsenite of soda so that the diluted liquid would contain 1 oz. arsenite of soda per gallon: down to half that amount, however, could be used. These limits are represented by 8 lb. of arsenite of soda 80 per cent. down to 4 lb. in the concentrate.

**Borate of Soda,** $Na_2B_4O_7$.—Borax occurs naturally in the lakes of

Asia and Italy, from which it is extracted by evaporation and crystallization.

**Preparation.**—By gradually adding 100 lb. of Tuscan boric acid to 125 lb. of soda crystals dissolved in 20 gallons of water and then heating by steam. The mixture is concentrated to 30° Bé., and cooled slowly; crystals of borax form at the bottom of the receiver. The double borate of soda and lime, or boronatrocalcite, is widely distributed in America; it is now used to manufacture a large amount of borax, obtained by boiling this product with carbonate of soda.

**Properties.**—Borax is freely soluble in water. One hundred lb. of borax dissolve in 120 gallons of cold water and the same amount in 20 gallons of boiling water. Its solutions react alkaline. Borax is used in medicine as an antiseptic, especially in throat and mucous affections. It is used to preserve meat and putrescible liquors. Werncke found it more active from that point of view than boric acid. Its antiseptic and bactericidal capacity is, however, very weak. Kuhn found that it only acted in 2 per cent. solution. Schwartz, however, found that the bacteria of the infusion of tobacco were exceptional, and that a 0·5 per cent. solution had already a certain effect on these microbes. Wenckiewicz found that it had no action on *Penicillium glaucum* until its solution reached 1·4 per cent. Borax exerts a poisonous action on plants. By watering haricots with a very dilute solution of borax Peligot first induced chlorosis, then death.

**Use.**—Borax has been recommended in 5 per cent. solution in America against the *Peronospora viticola*, de By. (mildew of the vine). At that strength it can check the disease, but its use is not without drawback, for it burns the leaves of the vines treated. Care should be taken to wash these a few hours after treatment. Muhlberg found borax solutions did not kill the *Schizoneura lanigera*, Hausm., against which it had been recommended. If the manure is not wanted for field or garden work, borax may be used for destroying the larvæ of house-flies in manure-heaps. Applied in the proportion of 62 lb. per 10 gallons of water for every 8 bushels of manure, borax solution will be quite as effective as the hellebore solution, and will be much cheaper. A daily sprinkling of the refuse heaps and of stable, cowshed, or out-house floors with one of the solutions is recommended.

**Carbonate of Soda,** $Na_2CO_3$.—**Preparation.**—By the Solvay process principally. A concentrated solution of common salt is first saturated with ammonia, then a prolonged current of carbonic acid is passed through; bicarbonate of ammonia is produced, which acts on the common salt to convert it into carbonate of soda. The precipitate is filtered, drained, and calcined. The Leblanc process is almost superseded, but the ammonia-soda process is making way.

**Properties.**—Carbonate of soda crystallizes in prisms; the crystals lose their water of crystallization at the ordinary temperature. Heated, they melt in their water of crystallization, dry, and form calcined carbonate of soda (soda ash) which is an amorphous white powder containing no water. Soda crystals are much more soluble in hot water than in cold: the maximum solubility is at 38° C.; 1 gallon of water dissolves 6·04 lb. at 14° C., 166·6 lb. at 38° C., and 44·5 lb. at 104° C. Carbonate of soda in solution has a strong alkaline reaction.

**Action of Carbonate of Soda on Plants.**—Around alkali works the presence of this salt, carried by the wind, does much damage. Eventually the carbonate of soda, covering the leaves with a white layer, more or less thick, causes them to drop off, and kills the trees themselves. Rye suffers much from contact therewith; the ears are almost empty, and the few grains which they contain are shrivelled and blackish. When plants have been in contact with carbonate of soda the analysis of the ash reveals a quantity of soda superior to the normal quantity. The straw of cereals is more brittle, and contains less silica. Carbonate of soda acts like carbonate of potash; when it is a case of neutralizing the acidity of certain marshy lands carbonate of soda may play the part of lime, and the nitric ferments, which cannot act except in slight alkaline media, may thereby modify the flora of the field. In such conditions carbonate of soda, in small doses, may exert a favourable influence on vegetation.

**Action on Fungi.**—Wuthrich treated the spores of different fungi with sodium carbonate with the following results: A solution of 0·053 per cent. prevents the conidia of the *Phytophthora infestans*, de By., from producing zoospores, but it does not injure their direct germination; life is only arrested by immersing the conidia in a 0·53 per cent. solution. As to the conidia of the *Peronospora viticola*, de By., Wuthrich found sodium carbonate more energetic; a 0·053 per cent. solution hindered the growth of the spores, and a solution of 0·53 per cent. stopped it entirely. The uredospores of *Puccinia graminis*, Pers., show, more than any other spores, a great resistance to carbonate of soda solutions, but germination is hindered by 0·53 per cent. solution and stopped entirely by immersion in a 2·65 per cent. solution.

**Action on Insects.**—All soft-skinned insects are sensitive to strongly alkaline substances, but these substances in themselves are not very powerful insecticides; they are, therefore, combined with toxic substances.

**Use.**—Carbonate of soda enters into the composition of certain copper bouillies, but it has no other function than to decompose the blue vitriol into carbonate of copper and sulphate of soda. An excess of carbonate of soda must be avoided in the preparation of Burgundy or cuprosodic bouillies, because these evaporating on the leaves may give rise to the same bad effects as carbonate of soda and cause the leaves to drop.—*Black Spot on Roses.*—U. S. Lodge states that sodium carbonate meets the five requirements which are necessary in the spray to control Black Spot: "Killing effect on the spores of the various fungi, non-poisonous character, cheapness, ease of making up, and lack of any tendency to damage either flower or foliage. The common form is a crystalline salt containing a large percentage of water crystallization; in the dry form this excess water is removed. Upon standing for a time, the crystalline salt has a tendency to convert a portion of itself into bicarbonate of soda. The proper strength of the solution used is important. Too strong a solution will crystallize upon the foliage and eventually destroy a portion of it; too weak will not have the desired effect. If the crystalline salt is used, the proper proportion is approximately 1½ oz. to the gallon of water. If the dry salt is used, then ¾ oz. to the gallon of water should be used. The chemical should be dissolved in a small quantity of very hot water, and then the balance of the water added. It will be found advisable to add whale-oil soap, for this solution will not 'stick' to foliage or stems. Sufficient force should be used in spraying to force the solution through the bushes, so that leaves and stems are well covered on top and underneath. The plants should be sprayed twice a week with clear water to wash off the foliage, and the washing should be followed within six hours by the above spray. Three days is about as long as the sodium carbonate will remain active enough to perform its purpose. In that time a certain proportion of the chemical is taken up by the leaves in the form of carbonic acid gas and used as food."

**Sodium Cyanide.**—The British Ministry of Agriculture recommends that an article sold as sodium cyanide for agricultural and horticultural purposes should be capable of evolving (when treated with an acid) not less than 54 per cent. of its weight of hydrocyanic acid.

The procedure to be followed in the fumigation of foreign cotton as a preventive against *Pectinophora gossypiella* is given in an order of the U.S. Federal Horticultural Board. The rate is 6 oz. of sodium cyanide per 100 cubic feet. The cotton to be fumigated is placed in the fumigating chambers, the doors to these chambers are closed, and the air is exhausted until the vacuum gauge registers 25 inches. At this stage the gas is generated in a retort connected with the large chamber. The valve of the connecting pipe is opened; after the expiration of 15 minutes air is allowed to pass through the generator for 5 minutes for the purpose of removing any gas which may be present. The air valve on the fumigating chamber is then opened and the air allowed to rush in until the gauge registers 5 inches. The cotton then remains in the chamber for 1 hour and 40 minutes, making the total process of fumigation 2 hours. After the completion of the exposure, to remove the gas the pumps are run again and a vacuum of 25 inches is established. At this stage the valves are opened and the pumps kept running for some time to complete the washing out of the gas from the bales. The pumps are then stopped and the doors of the chamber opened so that the cotton can be removed and another lot put in. The results of tests indicate that such fumigation of cotton did not cause any deterioration of the cotton, either as to percentage of waste, spinning qualities, tensile strength, or bleaching, dyeing, or mercerizing properties of the cotton.

The action of sulphuric acid on sodium cyanide is identical with its action on the potassium salt (see below, Chap. VII), and is as follows:—

$$2NaCN + H_2SO_4 = Na_2SO_4 + 2HCN.$$

According to this reaction, 1 oz. (avoirdupois) of sodium cyanide requires 1 oz. (avoirdupois) of sulphuric acid, $H_2SO_4$, or 1·07 oz. of commercial sulphuric acid containing 93 per cent. of sulphuric acid, which is equivalent to 0·56 fluid oz. To get the best yield of gas the sulphuric acid must be in considerable excess, when the reaction would be:—

$$NaCN + H_2SO_4 = NaHSO_4 + HCN,$$

or for each ounce of sodium cyanide there would be required 2·14 oz. (avoirdupois) of 93 per cent. sulphuric acid, equivalent to 1·12 fluid oz.

**Sodium Fluorsilicate.**—Sodium fluoride has been proved efficient in the U.S.A. for killing roaches and chicken lice, but cannot be used on plants because of its scorching effect, due to solubility. As a result, the use of sodium fluorsilicate has been tried with successful results in connection with plants. Field trials were made with a dusting powder of hydrated lime nine parts and the fluorsilicate one part by volume, and was found effective for the destruction of the Mexican bean beetle, the Colorado potato beetle, the potato flea beetle, the bean leaf beetle, and the tobacco hornworm. Under laboratory conditions, its use was also efficient for the cotton boll weevil. At the Department of Insecticides and Fungicides Rothamsted Experimental Station, Harpenden, shoots of hazel were sprayed with very fine suspensions of sodium and potassium silicofluorides in water, allowed to dry, and transferred to lamp glasses fitted with a cork at the lower end through which the stalk dipped into water, the open top of the vessel being covered with muslin. Ten larvæ of *Selenia tetralunaria*, Hufn., were then placed on each twig and observed from day to day. The state of affairs after four days was as follows :—

| | Per cent. | Unaffected. | Slightly affected. | Moribund. | Dead. |
|---|---|---|---|---|---|
| Sodium silicofluoride . | 1 | — | — | 1 | 9 |
| | 0·75 | — | 2 | 4 | 4 |
| | 0·5 | 7 | — | 1 | 2 |
| | 0·25 | 9 | — | — | 1 |
| Potassium silicofluoride . | 1 | 1 | — | — | 9 |
| | 0·75 | 1 | — | — | 9 |
| | 0·5 | 5 | — | 3 | 2 |
| | 0·25 | 10 | — | — | — |

The toxicity was slightly (probably not significantly) less when 1 per cent. of saponin was added to the spray fluid. The foliage was uninjured by the treatment.

## CHAPTER VII

POTASSIUM HYDROXIDE (CAUSTIC POTASH)—POTASSIUM SULPHIDES (LIVER OF SULPHUR)—POTASSIUM CHLORIDE (MURIATE OF POTASH)—POTASSIUM NITRATE—POTASSIUM SULPHOCARBONATE—POTASSIUM XANTHOGENATE—POTASSIUM CYANIDE (PRUSSIC ACID)—POTASSIUM SULPHOCYANIDE.

**Caustic Potash,** KHO.—**Preparation.**—By decomposing carbonate of potash in solution in water by lime a precipitate of carbonate of lime is formed, and potassium hydroxide enters into solution :—

$$\underset{\text{Potassium carbonate.}}{K_2CO_3} + \underset{\text{Calcium hydroxide.}}{Ca(OH)_2} = \underset{\text{Potassium hydroxide.}}{2KOH} + \underset{\text{Calcium carbonate.}}{CaCO_3}$$

**Properties.**—Caustic potash is a white deliquescent solid; exposed to moist air it absorbs water and carbonic acid. Potash, even in dilute solution, is a strong caustic which softens and gradually dissolves the skin; it traverses and perforates the mucous membranes; it is a strong poison, which should be handled carefully. It is used in surgery as a cautery. [Antidote, vinegar.]

**Use.**—Potash solutions have been used in America against different plant lice, which, owing to the chitinous protections covering them, greatly resist insecticides. The caustic nature of potash gives access to the insect by removing these obstacles. (See above *re* Caustic Soda.)

**Potassium Sulphides,** $K_2S$ to $K_2S_5$.—**Preparation.**—Potassium monosulphide is prepared by heating carbon and potassium sulphate; or from caustic potash, by saturating a 30 per cent. solution with hydrogen sulphide, when potassium hydrogen sulphide and water are formed :—

$$KOH + H_2S = KHS + H_2O.$$

The same amount of 30 per cent. caustic potash is afterwards added, which reduces the hydrosulphide to the monosulphide :—

$$KHS + KOH = K_2S + H_2O.$$

To obtain the polysulphides it suffices to heat the monosulphide with 1, 2, 3, or 4 atoms of sulphur.

**Liver of Sulphur** is a mixture of polysulphides, but it contains especially the pentasulphide of potassium. It is preferably obtained by heating to redness in a crucible equal parts of sulphur and carbonate of potash. By the action of heat the carbonic acid is disengaged and the sulphur combines with the potassium. When the disengagement of carbonic acid is finished, the liquid is run on to an iron plate where it solidifies immediately; it is then broken up and preserved out of contact with air. It forms a reddish-brown solid which smells of rotten eggs.

Formulæ of the British Ministry of Agriculture :—

(*a*) Potassium Sulphide (Liver of Sulphur) Wash. (Original formula.)

| | |
|---|---|
| Potassium sulphide | 5 oz. |
| Soft soap | ½ lb. |
| Water | 10 gall. |

In preparation the soap and potassium sulphide are dissolved in the water.

(*b*) Potassium Sulphide (Liver of Sulphur) Wash. (Lloyd's formula.)

| | |
|---|---|
| Potassium sulphide | 1 oz. |
| Flour | 1½ oz. |
| Water | 2 gall. |

" Place 14 pints of water in a bucket and add 1 oz. of liver of sulphur which will completely dissolve while the flour paste is being prepared. Make 1½ oz. of ordinary wheat flour into a smooth paste with a very little water. Add water to 2 pints till the mixture is as thin as milk and as free from lumps. Boil this until it froths up, stirring it all the time. Add it to the solution of liver of sulphur and mix thoroughly. Apply with a hand or knapsack sprayer and wet the plants all over. The flour paste must be used the day it is prepared, and any mixed spray remaining at night must be thrown away." This wash is recommended for use against " red spider " on fruit trees.

**Properties.**—The sulphides are very deliquescent and soluble in water in all proportions. They must be kept out of contact with air; carbonic acid in presence of moisture rapidly decomposes them into potassium carbonate and hydrogen sulphide. Solutions of the monosulphide are colourless, those of polysulphides, on the other hand, are yellow. Sulphides retain the alkaline properties of caustic potash, attenuated by sulphur. In medicine, sulphides are used to treat skin diseases due to acarium. Plants do not stand spraying with sulphide solutions, these being generally used very dilute. The sulphuretted hydrogen given off by decomposition is poisonous to the plant in a 0·75 per cent. dose, but it is only formed gradually, so that the amount in contact with the plant is not sufficient to cause any ill effect. Leaf burning is less frequent than with sublimed sulphur.

**Use.**—Sulphides are used to combat: (1) *Cryptogamic diseases*, either by spraying the plants or by immersion to disinfect the seed against anthracogenic parasites. (2) *To kill insects*. To impart more adherence and a longer action, a soap and glycerine emulsion is used. Polysulphides of potassium are used in the same proportion as sulphur, for they decompose under the action of carbonic acid and air and organic acids into potash salts, hydrogen sulphide, and sulphur :—

$$K_2S_5 + CO_2 + H_2O = K_2CO_3 + H_2S + 4S.$$

The sulphur is precipitated in a fine state of division, and thus its anticryptogamic properties are at a maximum. It can thus be said that the action of polysulphides is appreciably identical with that of sulphur, and especially of precipitated, impalpable sulphur if used in the same temperature conditions. In studying their application it will be seen that they have entered into current practice as substitutes for sulphur in killing numerous *Erysipheæ* and to stop the development and extension of certain fungi by the destruction of their *conidiophores*. In sulphides the caustic action aids that of sulphur. Not only do sulphides have a decided action on fungi and their spores, but the potassium carbonate formed by their decomposition has a decided action on fungi, whose growth it prevents. The growth of conidia of *Phytophthora* and of *Peronospora* is stopped by a 0·7 per cent. solution, their zoospores being no longer able to develop. The spores of *Ustilago Carbo* and of *Claviceps purpurea* as well as the uredospores of *Puccinea* are more resistant than the former, for a 0·7 per cent. solution hardly hinders their growth, whilst a 3·5—7·5 per cent. solution stops it.

As insecticides, sulphides act in virtue of their caustic properties, and the sulphuretted hydrogen given off by their decomposition, this gas being for insects almost as poisonous as prussic acid. It is, moreover, asserted in medicine that sulphides used in 5—20 per cent. solution in skin diseases, such as itch, act on the parasites by the sulphuretted hydrogen formed in contact with the organic acids of the transpiration and the carbonic acid of the air.

**Use against Bacteria.**—Sulphides retard putrefaction and kill microbes (Amsler). It has been tried to utilize this property to treat plant diseases of bacterian origin, such as potato scab. The bacteria which causes this disease of the potato is found, according to Bolley, in the living tissues of the periphery of the tubers and never penetrates deeply; it is aerobic. Bolley has submitted tubers so attacked for twelve hours to the action of a 0·3—0·4 per cent. solution of potassium sulphide before planting them. At that strength the causticity of the sulphide is not sufficient to injure the tubers. An appreciable effect was obtained, but the sulphide has not the radical effect of mercury bichloride. The results obtained by the sulphide are still defective—5 per cent. of healthy tubers against 1 per cent. in a blank field.

*Gum Disease of the Olive* (Mal di Gomma of the Italians).—Swingle and Weber advise to combat this disease by potassium sulphide: 18 kilogrammes (39·6 lb.) of potassium sulphide are dissolved in 15 litres (3·3 gallons) of water; to this paste 12 kilogrammes (26·4 lb.) of 98 per cent. caustic soda are added and energetically stirred. The mass heats, boils, and melts. As soon as boiling is over the bulk is made up to 100 litres (22 gallons) with water. The cankers and wounds formed by the disease are cleaned, diluted before use with an equal bulk of water; the roots, even sound ones, are stripped and watered with a solution of this sulphide in 10 parts of water.

**Use against Fungi.**—**Pickling of Seed-Corn.**—Dilute solutions of potassium sulphide prevent the growth of fungi and their spores and may kill them if of a certain strength. The action of the sulphide is not the same on all spores, *e.g.* it is almost *nil* on the spores of *Phytophthora phaseoli*, Taxter (Lima bean mildew). Hitchcock and Carleton remarked that a 1 per cent. solution not only did not destroy the uredospores of *Puccinia graminis*, Pers. (black rust) and *Puccinia coronata*, Corda (coronated rust of oats), but rather accelerated their germination. By numerous experiments on rusts Galloway came to the same conclusion. The disinfection of grain in 0·75 per cent. solution made no diminution in the rust. By spraying winter wheat no appreciable result was obtained unless spraying with a 0·5 per cent. solution was repeated every ten days. Under such conditions he obtained 1 diseased plant against 24 in the blank plot. If twenty days' interval occurred between the sprayings the rust did not diminish but the harvest was a little better. Kellermann and Swingle were the first to observe the sensitiveness of the spores of smut to sulphide, especially the loose smut of oats. Jensen tried if grain could not be disinfected by sulphide against smut. The results which he obtained were surprising, and he did not hesitate to advise it in place of steeping in hot water recommended by him some years previously. Numerous experiments show, however, that the sulphide is not capable of rendering better services than the Jensen hot-water treatment or that of Kuhn with blue vitriol or that by mercuric chloride. It generally gives very irregular and sometimes imperfect results, for example, against *Smut of Wheat* (Rostrup). It has, however, a serious application in the disinfection of oats, where it is superior to any other treatment in destroying the spores of *Ustilago avenæ*, Rost. (loose smut of oats). This treatment is practised in Denmark where it is highly esteemed. Steeping should last twenty-four hours in a 0·75 per cent. solution.

*Helminthosporium gramineum*, Eriks. (black mould of cereals).—Kolpin Kavn found steeping grain in the sulphide is a good precaution against this disease.

**Spraying with Dilute Solutions.**—The *Erysipheæ*, the mycelium of which is not protected by the tissue of the plant attacked, may be combated by potassium polysulphides. Owing to their decomposition the sulphur is deposited between the filaments spread on the surface of the organs attacked, and acts in a more certain manner than sulphur used against the same disease. In spite of their properties the sulphides of potassium are not used to combat the oidium. Gardeners use them against *Microsphæra grossulariæ*, Wallr. (gooseberry leaf-mildew); *Sphærotheca mors uvæ*, B. et C. (American gooseberry mildew), which they cure radically. Close prefers a 0·3 per cent. solution of potassium sulphide to the fungicides, usually employed by sol, formol, and bouillie bordelaise. Goff advises spraying with a 0·2—0·4 per cent. solution as soon as the leaves appear, and to renew it after each heavy rain until the plants are completely in leaf, and from time to time in summer. He obtained the following results: The fruit garden check plots showed 11·3 per cent. diseased plants, after 0·2 per cent. treatment 7 per cent., and after 0·4 per cent. 1·7 per cent. of diseased plants.

*Sphærotheca pannosa*, Lev. (rose and peach mildew).—This fungus may be combated efficaciously by potassium sulphide. Vesque recommends spraying with 1 per cent. solutions, Mohr 2 per cent. liver of sulphur, to which he adds 2 per cent. of glycerine to render it more active and adherent. A concentrated bouillie is prepared by dissolving 200 grammes of liver of sulphur and 200 grammes of glycerine in a litre of water (say 2 lb. of each in a gallon of water) and the solution kept out of contact with air until required for use, when it is diluted with ten times its bulk of water.

*Sphærotheca Castagnei* (hop mildew).—Salmon recommends 0·1 per cent. solutions, Selby 0·2 per cent. solutions.

Amongst the fungi living in the interior of plants which cannot be reached, a certain number may be combated by destroying the conidiospores which contribute to their rapid propagation. These are :—

*Alternaria brassicæ f. nigrescens*,[1] Peglion (scorching of the leaves of the melon).—Sturgis used potassium sulphide with much success.

*Sphærella fragariæ*, Sacc. (spotting of the leaves of the strawberry).—Potassium sulphide has been used successfully in America by Buffum and Arthur against this parasite of the strawberry to prevent its too great extension.

*Guignardia Bidwelli*, Viala et Ravaz (black rot).—Galloway obtained satisfactory results with 0·1 per cent. solutions of liver of sulphur: blank vines 65·64 per cent. of sound grapes; vines sprayed six times, 75·17 per cent. of sound grapes. This treatment cannot compete with that of copper salts, because notwithstanding its less efficacy it is not quite harmless to the vine leaves.

*Septoria Piricola*, Desm. (spotting of the leaves of the pear).—Duggar used potassium sulphide with success, but found it less efficient than bouillie bordelaise.

*Cladosporium fulvum*, Cooke (tomato disease).—The mycelium, which extends between the cells of the parenchyma, cannot be reached, but the conidiophores may be destroyed. Liver of sulphur acts better than sulphur in this instance (Mohr).

*Glœosporium frutigenum*,[2] Berk. (bitter or tardy rot of fruit).—To prevent this, Galloway and Nijpels spray the apples before maturity, in August, with a 0·4 per cent. solution.

*Fusicladium dentriticum*,[3] Fuckel (apple scab); *Fusicladium pirinum*, Fuckel (spots of the pear).—Goff found that on apple-trees frequently sprayed with 4 per cent. solutions of liver of sulphur from the birth of the leaves, and renewed after each heavy rain, the amount of diseased apples is appreciably diminished.

**Use against Insects.**—Potassium sulphide may be used as a caustic against delicate insects. It also destroys the tissues protecting grubs.

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[1] ALTERNARIA BRASSICÆ F. NIGRESCENS. *Roasting (Grilling) of the leaves of the melon.*—In the months of August and September when great heats are followed by rains the leaves of the melon are seen to dry up and brown. The fungus develops rapidly on the leaves with small yellow spots; as they get larger these spots end in big maroon spots which cover the whole leaf.

[2] GLŒOSPORIUM FRUTIGENUM (bitter rot of the apple).—This disease, prevalent in America and in England, is characterized by brown spots which are produced on the green apples and are covered by black dots, the pycnides of the fungus.

[3] FUSICLADIUM PIRINUM (pear scab, pear holes). *Fusicladium dentriticum* (apple scab, holes of the apple).—These two fungi are very analogous, and do the same damage, the one on the pear-tree, the other on the apple-tree. The *Fusicladium pirinum* attacks the leaves, branches, and fruits of the pear-tree. Numerous dark spots appear on the leaves which become pulverulent and of a black olive-green. *Fusicladium dentriticum* produces black velvety olive-green-covered spots on the leaves of the apple-tree, on the fruits brown or dark spots, sometimes isolated, sometimes confluent.

*Acridides.* Dubois observed the great sensitiveness of grasshoppers (Locusta) and their eggs to potassium sulphide. These eggs touched by solutions of potassium sulphide do not hatch. Watering the soil with potassium monosulphide on the spot where the Acridides have laid their eggs may suffice to impede the invasions of the *Acridium migratorium* so formidable in Algeria.

*Eriocampa adumbrata*, Kl. (the pear-tree saw-fly).—Taschenberg recommends powdered fresh liver of sulphur spread like sulphur on the trees. Solutions of the sulphide are used with success against the caterpillar protected by a silky tissue which render them inaccessible to ordinary aqueous insecticides. Potassium sulphide by its caustic action softens and finally decomposes the tissues, and penetrates to the caterpillar which then dies owing to the sulphuretted hydrogen disengaged.

*Cochylis ambiguella*, Hubn. (cochylis of the vine).—Schmidt-Achert recommends as very efficacious against this caterpillar a 2—5 per cent. solution of liver of sulphur sprayed on the flowers and on the grapes; Schafer, on the other hand, did not obtain good results by this treatment.

*Hyponomeuta Malinella*, Zell. (hyponomeute of the apple-tree).—Bach found a bouillie made with 1200 grammes of soft soap and 200 grammes of liver of sulphur in 100 litres of water (say 12 lb., and 2 lb. in 100 gallons of water). This bouillie can be used with success against all caterpillars that live in company in a spun refuge.

*Tingis Piri*, Fl. (Tigre du Poirier).—Montillot recommends two or three coats with the brush in winter, at intervals of a fortnight, on the branches and trunks of pear-trees with a preparation made thus: 2 lb. of potassium monosulphide is dissolved in the requisite amount of water; it is withdrawn from the fire and 2 lb. of flowers of sulphur gradually added.

*Plant-lice.*—Moss recommends a mixture of soap and liver of sulphur against lice in general. Thumen regards 2½ per cent. solutions of potassium sulphide as good. The phylloxera is absolutely refractory to the action of potassium monosulphide.

*Phytoptides.*—The acari, which by irritation of the tissues of the plant produce degeneration of the latter, become manifest by felt-like growths known as *crinoses* or by peculiar swellings of bright-coloured tints as is seen on the pear when it has the Cloque (brown rust), may be destroyed by the sulphides. Emulsions containing 3—4 per cent. of sulphur must be used at the moment when the acari have not yet produced the excrescences which protect them so efficaciously. Smith and Williamson advise to treat chiefly the *Eriophyes Piri*, Pgst., *Phytoptus Piri*, by two sprayings, one before the opening of the buds, and the second after collecting the fruit, or even spraying with a concentrated emulsion in winter followed by a weaker one after plants have come into leaf.

**Potassium Chloride (Muriate of Potash),** $KCl$; **Potassium Sulphate,** $K_2SO_4$.—**Natural Occurrence.**—Potassium chloride is found (500 grammes per cubic metre) in sea-water. Potassium chloride and sulphate of potash form vast underground deposits at Stassfurth in Prussia and at Kalusy in Galicia. In these mines the different salt beds have a different composition. Below vast deposits of rock salt deposits rich in sulphate of potash are found under the form of triple sulphate of lime, magnesia and potash (*Polyhalite*), then sulphate of magnesia and potash (*Kainite*), and finally double chlorides such as *Carnallite*. Carnallite, for example, contains 16 per cent. of potassium chloride, 20 per cent. of magnesium chloride, 25 per cent. of sodium chloride, 10 per cent. of magnesium sulphate, and 29 per cent. of impurities. For agricultural purposes these salts are generally used in the impure state as brought from the mine. If it be desired to purify them and to obtain pure potassium chloride, the saline mass is pulverized and dissolved in large cast-iron steam-heated vessels. The solution is allowed to deposit, then decanted, and left to crystallize; the potassium chloride crystallizes, entraining with it a little magnesium and sodium chlorides which are removed by washing with cold water. If potassium chloride be treated with sulphuric acid, which is done commercially in cast-iron vessels, hydrochloric acid is given off and potassium sulphate formed.

**Properties.**—Potassium chloride is very soluble in pure water. 320 grammes dissolve in 1 litre of water at 10° C., 570 grammes in 1 litre at 100° C. Potassium sulphate is less soluble, a litre of pure water dissolves 84 grammes at 0° C. and 260 grammes at 100° C.

**Action on Plants.**—Potash is a necessary plant food. In soils where potash is quite absent plants languish and finally die before maturing their seed. Such soils are rare. They are such as contain a large proportion of limestone, peat, or sand. Potash may be given to the plant as potassium chloride as well as the sulphate or nitrate. The crude salt from the mines is generally used for the purpose. If soil be dissolved by aid of sulphuric and hydrofluoric acids, and if the potash which it contains be isolated, enormous amounts are found per hectare. The German agronomists calculate this amount at 30 –40 tons per hectare (12—16 tons per acre). Berthelot found 35 tons at Meudon (14 tons per acre) and Dehérain 32 tons at Grignon (12·8 tons per acre). This potassic mass is not in a state of soluble chemical combination, but it may be dissolved by the acid juices of the roots which it appropriates in sufficient amount. When potassic manures are added to soils of this nature, and they form the great majority, no benefit accrues to the plant, and the spots where they are applied cannot be recognized, no increased yield being obtained. Potassium manures are only useful as a supplementary material when the soil does not contain it in any form. Then its influence makes itself felt especially when the crop is sustained by other chemical manures such as sulphate of ammonia, nitrate of soda, and superphosphate. Farmyard dung, which contains 5 kilogrammes (11 lb.) of potash per ton, suffices with the (potash) salts contained in the soil to meet the requirements of agriculture. The belief in the great efficacy of potash salts in all soils, established by Liebig, has not been confirmed in practice. An excess of potash salt may, on the contrary, be injurious to certain plants. Heinrich was the first to observe the injurious effects of certain salts, such as potassium chloride and magnesium chloride, nitrate of soda and sulphate of ammonia on adventitious plants. Steglich has specially studied the action of potassium chloride on farm crops with the following results :—

Table XVIII.—*Showing the Action of a 30 per cent. Solution and a 15 per cent. Solution of Potassium Chloride (Muriate of Potash) on Farm Crops.*

| Crop. | 30 per cent. solution. | 15 per cent. solution. | Crop. | 30 per cent. solution. | 15 per cent. solution. |
|---|---|---|---|---|---|
| Grain . | Injurious fleeting | Disappears in 5–8 days | Lupin . . | Deadly | Deadly |
|  |  |  | Flax . . | ,, | ,, |
| Beets . | Nil | Nil | Mustard . | ,, | ,, |
| Potatoes . | Deadly | Deadly | Charlock . | Very injurious | Nil |
| Peas . | ,, | Slight | Sorrel . . | ,, | Slight |
| Haricots . | ,, | ,, | Polygonium . | Deadly | Nil |
| Trefoil . | Nil | Nil | Horse-tail . | Injurious | ,, |

On the other hand, a 6 per cent. solution of kainite has no injurious effect on the most tender part of the plant.

**Use.—As Pickle for Seed-Corn Smut.**—G. Arieti tried to disinfect seed-corn against smut by steeping it for twenty-four hours in a 0·5 per cent. solution. At that strength potassium sulphate has no injurious action on the germination of the grain, but neither is its action on the spores very pronounced. A 2 per cent. solution renders the spores of *Tilletia* (bunt) inactive, but the seed already suffers. G. Ville, having observed that a want of potash in the soil seems to favour the development of the *Phytophthora infestans*, de By. (potato disease), recommended the use of potassic manures to combat it in a preventive manner. Care must be taken, however, not to use larger quantities than 600 kilogrammes per hectare, say 528 lb. per acre, for at that dose potash salts diminish the yield in starch. These salts are also employed against phanerogamic parasites, such as dodder.

*Cuscuta epithymum*, Murray (dodder of trefoil and lucerne).—Their sensitiveness to metallic salts is very great, and these parasites may be easily destroyed by watering the fields with such solutions. In the same way as the sulphates of iron and copper, green and blue vitriols, which give good results, the sulphate of potash may also be used. Vesque recommends to dust with this product in a heavy morning dew the plots invaded by dodder. Next morning, after this treatment, the fields of trefoil and lucerne present a lamentable appearance; all the plants are brown and look as if burned, but the effect of sulphate of potash on *Leguminosæ* is only fleeting, and in eight days these plants have resumed their vitality, whilst the dodder is destroyed to such an extent that it does not reappear the following year. The dose to use is from 200—250 grammes per square metre, say 7—8 oz. per square yard.

*Equisetum arvense*, L. (meadow horse-tail).—This plant, which contains aconite, is injurious to cattle. Tacke advises, to free crops infested with it, to water them with a concentrated solution of potassium sulphate; the gramineæ can resist this treatment, whilst the horse-tails die.

*Heterodera Schachtii*, Schm. (nematode of the beet).—As a sequel to Liebig's researches, concluding that potash is a necessary food of this plant, it was observed that potash salts used in beet growing, up to a certain dose, remedied the exhaustion of the soil. The general opinion was that such salts acted by their nutritive properties and replaced the potash removed by the beet. But after it was found that the exhaustion of the land by this crop was due in great part to an excessive growth of small worms, *nematodes*, Hollrung tried the action of potash salts on their larvæ. He remarked that the latter, more sensitive than the adults, died in forty-eight hours in a 1 per cent. solution of potassium chloride and in three hours in a 5 per cent. solution. Potassium sulphate is less active in a 1 per cent. solution as it takes ninety-six hours' immersion to destroy the larvæ, and has the same toxicity as potassium chloride in a 5 per cent. dose. To succeed, the dose used must be considerable; instead of using pure sulphate, the double salts from the mines, kainite or carnallite, are used, but these are less active than the pure salts. Hollrung has observed that in big doses these salts are unfavourable to the formation of sugar in the beet. There are no great advantages in using potassium chloride or sulphate in heavy doses to remedy the exhaustion of the land, for the effect is somewhat illusory. This practice has moreover been abandoned since, as the outcome of Aimé Gerard's researches, arable land may be sterilized by large doses of carbon disulphide.

*Agriotes lineatus*, L. (striped wire-worm).—Comstock and Slingerland ascribe insecticide properties to potassium sulphate against the adults. Smith regards a 12 per cent. solution of kainite as an excellent insecticide. But Marlatt, who used big doses of kainite, against wire-worm (Elaterides, click beetles), got no appreciable result. Mineral manures such as potash salts injure certain parasitic larvæ, *e.g.* :—

*Lachnosterna fusca*, Fröhl (May beetle); *Lachnosterna arcuata.*[1]—Chittenden found kainite very active. Possibly the larvæ of the Elaterides which are very mobile flee from soils which have been treated with big doses of potash manures. Opinions are too contradictory to admit that potash salts kill them.

*Agrotis segetum*, W. V. (common dart moth).—The grey worm, the caterpillar of this butterfly, is driven off or destroyed by watering the infested spots by a 12 per cent. solution of kainite.

*Jassus sexnotatus*, Fall.—Steglich uses kainite in a composition to combat this grasshopper: kainite 10 lb., carbolic acid 1 lb., soft soap 10 lb., in 100 gallons of water.

*Snails.*—Kainite is a specific against snails (Taschenberg).

**Nitrate of Potash,** $KNO_3$.—**Occurrence.**—Nitrate of potash, or saltpetre, occurs in nature; it is found in the great plains of China, India, and Egypt. It is extracted by removing the nitrated earth for a few centimetres and lixiviating it. The liquor is then run into large basins and evaporated in the sun.

**Chemical Preparation.**—By double decomposition of sodium nitrate and potassium chloride. By hot concentration of the solution the sodium chloride formed crystallizes, whilst the saltpetre, much more soluble when hot than common salt, remains in solution and does not deposit until after cooling.

**Properties.**—Saltpetre is very soluble in water, 10 gallons of water dissolve 15 lb. of saltpetre at 9° C., 85 lb. at 15° C., 246 lb. at 100° C.

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[1] LACHNOSTERNA ARCUATA (red cockchafer), the larva of which gnaws the roots of vines and strawberry plants in America.

(212° F.), 335 lb. at 118° C. At a great heat [igneous fusion] saltpetre is a powerful oxidizing agent.

**Action on Plants.**—Potassium nitrate, like potassium chloride, is a plant food, and what has been said concerning potash salts applies to potassium nitrate.[1] Concentrated solutions injure plants.

**Action on Fungi and their Spores.**—Wuthrich's researches on the action of metallic salts on the spores of fungi also include potassium nitrate. The growth of the conidia of *Phytophthora infestans*, de By., is not stopped by a 0·1 per cent. solution, but the formation of zoospores is prevented. The growth of the conidia is not hindered until a 1 per cent. solution is used. The zoospores are at once killed by this solution. The spores of *Peronospora viticola*, de By., are a little more sensitive. A 0·01 per cent. solution hinders their growth a little; with a 0·1 per cent. solution the conidia cannot form zoospores. Their motion is slackened, and after fifteen hours none reach their normal growth; a 40·4 per cent. solution interferes with the growth of *Ustilago Carbo* (smut), a 50·5 per cent. solution stops it. A 50·5 per cent. solution lowers the vitality of the spores of *Puccinia graminis*, Pers., but they are only killed with a 101·1 per cent. solution. A 101 per cent. solution does not destroy the vitality of the spores of *Claviceps purpurea* (ergot), Tul. Nitrate of potash therefore, even in strong doses, is deficient in real anti-cryptogamic properties. It has no toxic action, but merely exerts an unfavourable effect on the development of the spores by producing plasmolysis. Like many substances, potassium nitrate acts as an astringent when it is used in concentrated solution. As such it may prevent all cryptogamic evolution, but that is all its effect. If the spores, the growth of which has been momentarily suspended, are washed and replaced in good conditions, they generally develop normally.

**Use.**—*Ptereneus ribesii*,[2] Scop. (gooseberry and currant saw-fly); *Abraxas grossulariata*, L. (the magpie moth). Taschenberg uses against these two gooseberry pests a spray of a 1·2 per cent. solution of nitrate of potash.

The disease caused by *Botryodiplodia theobromæ* in cocoa plantations can often be cured by applications of nitrate of potash, and examination of the plants after this treatment shows that the fungous hyphæ are absorbed by the host.

**Carbonate of Potash,** $K_2CO_3$.—**Preparation.**—The impure commercial potash is obtained by incinerating terrestrial plants. This incineration is done where there are many forests and where the means of transporting wood are difficult. The ashes obtained, which do not contain more than 5—20 per cent. of carbonate of potash, are washed in casks and are exhausted after three or four washings. The collected liquors are evaporated and yield the salt which calcined in contact with air furnishes commercial potash, consisting mostly of carbonate of potash with a small amount of potassium sulphate and chloride. Other sources are, wool yolk, beet sugar molasses and cement dust. Large amounts of potash are produced in Russia by the incineration of sunflower stalks.

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[1] *Translator's Note.*—But the nitric acid is the predominating agent of potassium nitrate, and as a plant food puts it beyond comparison with other potash salts, the phosphate excepted.

[2] *Ptereneus ribesii* (gooseberry saw-fly).—The larvæ of these saw-flies attack different species of gooseberries, entirely deprive these shrubs of their foliage, and thus prevent the development of the fruit. During May the larva which is adult descends into the ground to turn into a grub. After three weeks the insect hatches and forms a new generation.

**Properties.**—Deliquescent. Dissolves in its own weight of water. Reaction strongly alkaline.

**Action of Carbonate of Potash on Plants.**—Used in agriculture carbonate of potash by its alkalinity plays the *rôle* of lime, *i.e.*, it corrects the acidity of the soil and utilizes the nitric ferments which can only work in a slightly alkaline soil. The nitric acid so formed increases the crop. Carbonate of potash can thus greatly alter the flora of an acid meadow. The reeds and rushes of the acid land disappear to the benefit of the useful *Gramineæ* and *Leguminosæ*. This sensitiveness of plants belonging to the *Cyperaceæ* and the reeds has been often remarked, and this product is utilized to destroy them. Noffray spreads wood ashes on meadows in wet weather or after a strong dew; the reeds and the rushes are burned and the *Leguminosæ* grow rapidly. The injurious action of carbonate of potash is not limited to these plants alone, it is very decisive on dodders, mosses, and lichens. The first are destroyed by spreading wood ashes on the clover fields in dry weather and watering afterwards. The result is satisfactory, but it cannot be compared to that got with green vitriol, for there often remains after treatment some immune parts which contribute to the propagation of the disease. Carbonate of potash may replace lime against mosses and lichens. Sorauer replaces the common process of liming the trunks of trees by coating them with a solution of 15 lb. of carbonate of potash in 15 gallons of water. This treatment not only frees the tree from the parasites sheltered under the fissures of the bark but does not colour the tree white like lime.

**Action on Fungi.**—Alkaline carbonates have no toxic action on spores of fungi, but at a certain strength they impede their growth. Tillet who observed this action found it sufficient to guarantee the seeds of black wheat. Disinfection by the lye from wood ashes has given appreciable results.

*Plasmodiophora brassicæ*,[1] Woronine (finger and toe).—As a preventive, Nijpels waters with carbonate of potash against the finger and toe so as to kill the spores of the myxomycetes and prevent infection of young plants.

**Action on Insects.**—Soft-skinned insects are generally very sensitive to alkaline substances and may be combated therewith. Soft soap and lime are of great service; carbonate of potash acting similarly has been recommended by some observers.

*Crioceris asparagi*, L. (the asparagus beetle).—The larva of this Coleoptera is very delicate and may be destroyed by spraying with the lye from wood ashes.

[1] PLASMODIOPHORA BRASSICÆ (finger and toe).—This disease is characterized by excrescences on the roots. It causes stoppage of growth and kills the plant. This disease may attack all varieties of cabbage, as well as beets, turnips, and radishes. The fungus which accompanies this disease belongs to the family of Myxomycetes, fungus consisting of a protoplasmic mass, the plasmodium, which changes incessantly in shape and which moves after the style of the lower organisms, the amœba.

*Haltica* (ground flea beetle).—To prevent these voracious Coleoptera from gnawing the young plants growing in the fields in the spring, Montillot spreads wood ashes on the seed beds. It is chiefly against the different species of plant lice that carbonate of potash has been found useful.

*Aspidiotus perniciosa* (San José louse).—Marlatt made numerous attempts to destroy this apple bug, so formidable in America, and obtained with 24 lb. of lye in 10 gallons of water, 85 per cent. lice killed; with 12 lb. 75 per cent.; with 6 lb. 50 per cent.; with 3 lb. 20 per cent. Carbonate of potash in itself acts injuriously on the lice, and as it is at everyone's disposal it may be tried in certain cases. But it will act more surely if it be used as an aid to certain toxic substances, petroleum, for example. Alkaline products, in fact, act on the mucus and the chitin so as to let the toxic substances reach the parasite and act on it more rapidly.

Wood ashes are also utilized to kill slugs, using preferably that from lime-kilns, as it still contains lime, the action of which aids the carbonate of potash. After a rain in the evening the ashes are spread broadcast on the seed beds of whatever nature; it exerts no injurious action on the plant but kills snails instantly on touch. It is well to water the plants next morning and recommence the treatment after sunset, In vineyards where slugs are dreaded vines are heavily dusted with ashes.

**Potassium Sulphocarbonate,** $K_2CS_3.H_2O$.—**Preparation.**—By agitating potassium monosulphide $K_2S$, with an excess of carbon disulphide. If a pure product be not desired liver of sulphur may also be used.

**Properties.**—Carbon disulphide acts as an acid towards alkaline sulphides and forms compounds therewith analogous in constitution to the alkaline carbonates, $K_2SCS_2$.

But these compounds are unstable: the moisture and carbonic acid in the air decompose them thus—

$$K_2CS_3 + CO_2 + H_2O = K_2CO_3 + CS_2 + H_2S$$

into alkaline carbonate, carbon disulphide, and sulphuretted hydrogen. Organic acids act in the same way. This decomposition goes on slowly in the air and in the soil, according to the moisture of the surrounding media and the richness in carbonic acid. The dry crystals contain 38 per cent. of carbon disulphide and can disengage 17 per cent. of sulphuretted hydrogen; 100 grammes of 40° Bé. commercial solution, which tests 55 per cent. of pure potassium sulphocarbonate, can give off on decomposition 20 per cent. of carbon disulphide, say 6 litres, and 9 per cent. of hydrogen sulphide. Potassium sulphocarbonate is in the solid condition a yellow crystalline very deliquescent body. But it is very difficult to obtain in that form, and the commercial article is liquid and marks 35—40° Bé. It is soluble in water in all proportions. [Alkaline sulphocarbonates treated by hydrochloric acid, then taken up immediately by water, yield a reddish-brown insoluble liquid which represents sulphocarbonic acid; it is used in therapeutics. It readily decomposes into $CS_2$ and $H_2S$. The sulphocarbonates which chemically contain carbon disulphide have no analogy with the sulphide mixed with tar, vaseline, oil, or soap, the use of which has been proposed to replace the pure sulphide.]

**Action on Plants.**—Sulphocarbonate when concentrated is a violent plant poison. The two gases [$CS_2$ and $H_2S$] which it liberates are likewise poisons, but their action is less energetic than that of the sulphocarbonate itself. Trials on healthy vines in 3-litre pots at different seasons of the year show that the vine is more sensitive in summer during the activity of the sap than in winter. Thus in August, vines do not stand a dose of 12 cubic centimetres of 40° Bé. with or without water, whilst a dose of 15 cubic centimetres may be given in winter, and even in April when already the vine has big buds. Now 15 cubic centimetres of sulphocarbonate of 40° Bé. can only disengage 3 grammes of carbon disulphide and 1·35 grammes of sulphuretted hydrogen, quantities which are supported by the vine in similar conditions, especially in emulsion in water. It takes more than 6 cubic centimetres of sulphide emulsified in 60 cubic centimetres of water to kill the vine at that period. Young adventitious plants (*Mercurialis annuæ*, *Polygonum aviculare*, *Calendula arvensis*, *Borrago officinalis*, *Erodium cicutarium*, *Ictaria viridis*) vegetating in the open air were treated at end of August with 100 cubic centimetres of sulphocarbonate of potassium or sodium of 45° Bé., reduced so as to make 2 litres of mixture, and spread in five holes in a square of 20-inch side; the plants only suffered in the immediate neighbourhood of the holes. Haricots planted in pots containing 2 litres of soil resist perfectly when watered with 250 grammes of a 2 per cent. solution of 45° Bé. potassium sulphocarbonate. Now, in practice, such strong doses are never used against insects. The toxic effect of potassium sulphocarbonate on plants is therefore almost negligible, whilst the dose is always poisonous to insects in a 0·0005 per cent. solution.

**Action on Fungi.**—Like carbon disulphide potassium sulphocarbonate in strong doses exerts an injurious action on the mycelium of fungi and their spores. Dufour and Mouillefert tried this compound to replace carbon disulphide against root blight, *Dematophora necatrix*, Hartig. They did not, however, obtain the good results which they anticipated. Dufour only registered 15 per cent. of cures after treating the stocks of vines suffering from the blight by a 2 per cent. solution at the rate of 3—5 litres per stock. It is true, that in these trials Dufour is far from having fed into the soil a dose of 150—200 grammes of carbon disulphide per square metre, as is the case in the treatment of root blight by carbon disulphide, for the 100 grammes of liquid sulphocarbonate used in this case only contained 15 grammes of sulphide. Sulphocarbonates cannot replace the sulphide in the treatment of root blight, for they are much dearer. It is only when the dose of sulphide is minimum, as in the case of some insects, that the sulphocarbonates present real advantages over carbon disulphide.

**Action on Insects.**—Sulphocarbonates, owing to their composition, are almost equally as efficient as potassium cyanide. The most dilute solutions have a manifest and rapid action on insects. Mouillefert examined very exactly the limit of action of sulphocarbonates used against the phylloxera in different ways.

1. *By Contact.*—By dipping the insects into dilute solutions, 1 in 200 of sulphocarbonate of 38° Bé., the insects were found dead in a

quarter of an hour; in 1 in 500, in one hour; in 1 in 1000, in one hour fifteen minutes; in 1 in 5000, one hour; in 1 in 10,000, two hours fifteen minutes; in 1 in 100,000, in twenty-four hours. In a blank flask only containing water the insects were not dead in twenty-four hours. The potassium sulphocarbonate of 38° Bé. used in these trials not containing 50 per cent. of dry sulphocarbonate, it may be said that the action of this product is deadly to the phylloxera in twenty-four hours in a 1 in 200,000 solution, say 0·0005 per cent. of dry salt.

2. *By the toxic vapours* disengaged by the decomposition of the sulphocarbonates. In a 2-litre flask with moist sides into which $\frac{1}{2}$ cubic centimetre of sulphocarbonate of potash of 40° Bé. had been run, the phylloxeras of an infested root suspended in this flask were killed in three hours. By running in 4 cubic centimetres of this product the insects were killed in half an hour. Now $\frac{1}{2}$ cubic centimetre contained 0·354 of dry sulphocarbonate capable of emitting by decomposition 0·14 gramme of carbon disulphide, or 40 cubic centimetres, and 0·06 gramme of sulphuretted hydrogen, or 40 cubic centimetres of gas, giving a total of 80 cubic centimetres of poisonous gas. It may therefore be concluded that $\frac{1}{2}$ cubic centimetre of sulphocarbonate is capable of producing in 2 litres of air an atmosphere with 4 per cent. of toxic gases.

In trials with $\frac{1}{10}$ cubic centimetres of sulphocarbonate, or with 100 cubic centimetres of a 0·1 per cent. solution, capable of producing 16 cubic centimetres of poisonous gas, and consequently an atmosphere of 0·8 per cent., the insects were killed in twenty-four hours. Now it is admitted that sulphuretted hydrogen destroys the phylloxera in twenty-four hours when the air contains 1 per cent. of this gas, and carbon disulphide when the atmosphere contains 0·5 per cent. of its vapours. It has been seen that the sulphocarbonate of potash disengages the same volume of these two gases. It follows that a mixture of equal volumes of sulphuretted hydrogen and carbon disulphide in the gaseous state would kill it in twenty-four hours with a solution of 0·75 per cent. strength. The result obtained is thus appreciably the same as that found for sulphocarbonate of potash. The mixture of the two gases produced by the decomposition of the sulphocarbonates kills the phylloxera in the same time as a mixture of the same qualities of these two gases acting simultaneously. But sulphocarbonates do not act only when they enter into decomposition, their solutions are in themselves powerful insecticides. Whilst both gases produced by the decomposition do not kill the phylloxera except at 0·0015 per cent. the sulphocarbonates in solution kill at 0·0005 per cent. Sulphocarbonates may thus be regarded as the most powerful of disinfectants, their aqueous solution being three times more powerful than sulphuretted hydrogen gas and carbon disulphide. Owing to this property, alkaline sulphocarbonates may be used to distribute through the soil substances highly poisonous to insects. There is no difference in the action of the different salts of sulphocarbonic acid, potassium, sodium, or calcium salts, but the former are generally used because they possess the advantage of carrying into the soil a certain amount of potash, which, in certain circumstances, may contribute to the rapid reconstitution of the damaged root system. The doses used in the laboratory to kill the phylloxera are not those which are of use on the large scale, because many causes contribute to reduce their efficiency. The doses tried by Mouillefert were at first very strong, and killed the vine treated as well as the parasites. The soil was watered from small vats near the stocks with a solution of 400 cubic centimetres of sulphocarbonate of potash of 38° Bé. in 5 litres of water, then with 8 litres of pure water. In other cases he used 220 cubic centimetres of sodium sulphocarbonate of 45° Bé. dissolved in ½ litre of water, distributed in four holes 60 centimetres deep placed in a radius of 35 centimetres around the stocks. The dose of 20 cubic centimetres of sulphocarbonate of 33° Bé. sufficed to kill the phylloxera without injuring the vine, but it is preferable to use per stock 50 –80 centimetres of sulphocarbonate at 37·2° Bé. dissolved in 10 litres of water to obtain complete success.

**Use.**—Sulphocarbonates were examined so as to be utilized in vine-growing in the destruction of the phylloxera. The results obtained by *sulphocarbonation* led to this treatment being tried on other insects, on which it has also given good results.

*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—*History.*—In 1874, Dumas proposed the sulphocarbonates for the destruction of the phylloxera, indicating at the same time a practical method for their manufacture. The Department of Agriculture and the *Académie des Sciences* entrusted two delegates, Cornu and Mouillefert, to make the necessary experiments to determine if the predictions of the learned chemist would be realized. Mouillefert made numerous experiments at the Cognac Viticultural Station, and was able to conclude that the sulphocarbonates, and especially potassium sulphocarbonate, were marvellous insecticides and also the best remedy against the phylloxera. In his remarkable research on the chemical products proposed for the destruction of the phylloxera he places the sulphocarbonates in the first rank of efficiency, and declares them to be alone capable of keeping a vine attacked by the phylloxera in a thriving condition, and to regenerate it if weakened by the disease.

In numerous experiments on vine stocks placed in different conditions of soil, age, and cultivation, the sulphocarbonates always effected an improvement. Those of which a part of the radicles was attacked were, after a year's treatment, finer plants than the non-diseased stocks. The stocks still more badly diseased and almost in the last extremity were appreciably improved and did not die like the untreated blanks.

Mouillefert in 1876 published the conditions which it is indispensable to observe to secure good results by this treatment. The useful application of alkaline sulphocarbonates to the cure of the vine requires: (1) That all the infected surface be treated. (2) That the poison be injected deep enough to reach all the phylloxera. The best method to secure perfect diffusion in the soil is to use water as the vehicle. The amount used may be greater, or less, according to the state and conditions of humidity in the soil, and according as it may be expected to rain, or not, but water cannot be completely suppressed. The more water added, the more complete the diffusion and rapid the action. The amount of sulphocarbonate required to treat a square metre to a depth of 80 centimetres, 31·2 inches, which gives 800 litres, say 1 cubic yard, of soil, is 30—40 cubic centimetres, 1—1⅓ fluid oz., which is comparatively very little. Without the aid of water it would be very difficult to distribute this small volume on the surface of the soil and equally impossible to cause it to descend to a sufficient depth to kill all the insects unless the soil be very permeable or rain falls at a propitious moment, which is exceptional. In all cases the direct use of water suffices if the quantity be abundant, whether the soil be compact, stony, or permeable, diffusion is always perfect. Alkaline sulphocarbonate solutions of 1 in 10,000 and even 1 in 20,000 being still poisonous in cultivation on the large scale, too great dilution need not be feared, in rendering diffusion more perfect, to make the remedy impotent. The best method of using sulphocarbonates consists in making flat receptacles in the soil, round the foot of each vine, and there distributing the poison. For this purpose 500 kilogrammes per hectare (440 lb. per acre), say 50 grammes per square metre, are diluted in 350 times its weight of water. After having poured the solution into the excavations it is well to pour on a little water to cause the poison to penetrate more deeply. When all the water is absorbed by the soil, the ground is put back into the pit and tramped down under foot. Sulphocarbonates may be used at any time of year, for the small dose has no effect on the plant, but it is preferable to use them whilst the sap is at rest. The water required to carry the poison into the depths of the soil being sometimes an obstacle to its use in many districts, the most convenient time for the application of sulphocarbonates is, then, that when rain is most abundant during winter, when the soil is already saturated with moisture. For small or medium scale cultivation, the best plan consists in placing the amount of sulphocarbonate required for a stock, say 50 grammes (1¾ oz.), in a 10-litre (2·2 gallon) watering-can, then to pour into each pit the entire contents of this watering-can, and afterwards pour an entire watering-can full of water on each stock. But it is preferable when possible to make a dilute solution in a large reservoir, and to draw out with the watering-can the amount required for each stock. On the large scale, Mouillefert and Hembert have designed plant intended to bring the water required for the treatment into vineyards. It consists of a steam engine, working suction and propelling pump which can send the water several kilometres, and to a height of 100—150 metres (328—492 feet). The pump, placed near a river or a lake, sends the water into a distributing channel forming a network of ramifications through the vineyard. The channels of the third order end in metallic vessels of 350—400 litres (77—88 gallons) in which the sulphocarbonate is dissolved; the workmen there draw the amount of insecticide required, and spread it with the watering-can around the stocks. With good organization the workmen need not carry the water more than 10 metres, say 33 feet. A man can then spread 1500—1800 litres, say 330—396 gallons, of water an hour round the vines. By this ingenious process, vines far from a source of water may be treated. But owing to the large amount of water required, which is 150,000 litres per hectare, say 60,000 litres (13,200 gallons) per acre, being awanting in many districts, this treatment has not been adopted everywhere. Its use also finds a drawback in the fact that the cost of sulphocarbonating is greater than sulphuring. It is true that it brings potash to the value of 50 francs per hectare, on to the land, but that is only really useful in districts where potash is deficient. Sulphocarbonates have therefore their place only in rich vineyards like those of Champagne, Burgundy, and Bordeaux. They should be preferred to carbon disulphide, the more so as they are much less dangerous for the vine. As Foëx justly remarks, it is a process to use in *de luxe* vineyards. There are in France vineyards that have been submitted to this treatment for fifteen years, and still in good condition. In France there are hardly more than 10,000—12,000 hectares (25,000—30,000 acres) treated annually by sulphocarbonates, and since the carbon disulphide treatment has been better studied this figure has a tendency to diminish, for the carbon disulphide treatment, like the sulphocarbonate, being annual the small doses of sulphide used in such conditions are not prejudicial to the vine and enable it to be kept in a good state of production. Unfortunately, whatever care be taken in applying these substances there will always be a certain number of phylloxera which escape the toxic action. If, theoretically, the sulphocarbonates are capable in small doses of entirely destroying the insects on the roots, it is not so in practice even in much stronger doses; different causes prevent the result from being so complete. But by the treatment the number of the phylloxera is so reduced as to enable the root hairs formed during the fine weather not to be entirely destroyed, and for the plant to nourish itself on the revival of vegetation. If the evil be not entirely removed it no longer forms an obstacle to the vine maintaining its vigour. The important point is to diminish the parasites, so that the vine may live with them without the crop suffering. The use of water as the vehicle of the sulphocarbonate being the great obstacle to the propagation of this marvellous insecticide, it has been tried whether mixtures with slaked lime would not likewise bring about a uniform distribution of the sulphocarbonates in the soil. It was Dumas who advised Mouillefert to try these mixtures, hoping that the lime, before its transformation into carbonate, would absorb the carbonic acid of the air and prevent the sulphocarbonate decomposing rapidly. In this way a powder would be got easy to spread in the soil at the foot of the stocks, which would preserve the alkaline carbonate intact whilst waiting for rain to carry it into the neighbourhood of the infected roots. Mouillefert, therefore, mixed 500 cubic centimetres of sulphocarbonate of potash of 37° Bé. with 1·2 kilogrammes of lime in powder and spread this mixture in winter at the foot of five stocks, previously stripped to the big roots on a radius of 35—45 centimetres; the earth was then put back into the holes. A fortnight later after a series of heavy rains the roots were examined; on all the top roots the insects were dead, but on the roots more than 40 centimetres (say 6 inches) the insects were not found dead until two months afterwards. Success would have been complete if it had not been that on the roots beyond the stripped radius the phylloxera were still living. According to the predictions of Dumas, the use of sulphocarbonate in these conditions may suffice, provided the mixture be spread all over the vineyard. To attain this object the proportion of lime must be increased greatly, and a mixture of 500 kilogrammes of sulphocarbonate with 5000 kilogrammes of slaked lime applied per hectare of vineyard (say 440 lb. and 4400 lb., 2 metric tons per acre). After spreading it would suffice to hoe the ground so as to mix it with the earth and protect it from contact with the air which would decompose it. From Laugier's experiments it would appear possible without hurting the vine gradually to extinguish the hotbeds of phylloxera infection, by aid of repeated mixed treatments of sulphocarbonate of potassium and carbon disulphide, applied opportunely and in suitable doses. This process, much used in Switzerland and Italy, appears to leave nothing to be desired.

**Disinfection of Vines and Graft Bearers.**—Sannino advises for this purpose sulphocarbonate of potassium in 0·05 per cent. solution; for disinfection to be complete immersion must last two hours. Dufour recommends for the disinfection of graft bearers coming from a phylloxera district the steeping of these in a solution of the following: sulphocarbonate of potash 0·5 per cent.; soft soap 5 per cent.; pyrethra powder 1 per cent.; tobacco juice 1 per cent.

*Carpocapsa pomonella* (*Pyrale du Pommier*) (the codlin moth); *Carpocapsa funebrana*,[1] Fr. (? *Carpocapsa nigricane*) (the red plum grub).—Montillot recommends watering the soil at the foot of the trees in autumn, after collecting the fruit, with a solution containing 1 per cent. of sulphocarbonate potassium.

*Cochylis ambignella*, Hubn. (cochylis of the vine).—Dufour tried to combat this insect by spraying with sulphocarbonate, but he did not kill the caterpillar. A bouillie containing 1 per cent. of sulphocarbonate and 3 per cent. of soap destroyed the insects but scorched the buds, which browned and finally dropped off. A 0·1—0·05 per cent. solution does not injure the plant and kills all underground larvæ.

*Formica* (ants).—An excellent means of destroying an ant-hill consists in the use of sulphocarbonate. A small trench is dug round the ant-hill and it is watered in the morning as far as possible, when the ants have not yet gone out, with a 0·5 per cent. solution. Half a litre to a litre of this solution suffices to destroy an ant-hill. After absorption of the liquid it is well to beat the earth down.

*Galeruca calmariensis* (galeruca of the elm); *Galeruca alni* (galeruca of the alder).—Sulphocarbonates in solution applied in August destroy these insects, which are so injurious to the trees in our parks and public promenades.

*Tipula oleracea* (meadow tipula).—To destroy the larvæ of tipula, carbon disulphide may be replaced by spraying meadows and fields with a dilute solution of potassium sulphocarbonate. Barthon, who recommends this treatment, advises to test previously the dose which will not injure the plants on which it is to be applied. A solution of 0·1 to 0·5 per cent. never injures plants and kills all underground larvæ.

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[1] CARPOCAPSA FUNEBRANA. *Pyralis of the Plum* (wormy plums, plum worms).—Small butterfly, 7 millimetres long, blackish with some spots and lines of a greyish-blue. In July the female lays its eggs on the still green plum. As soon as hatched the caterpillars penetrate into the fruit and remain there until maturity.

**Xanthogenate of Potassium,** $C_2H_5OCSSK$.—**Definition.**—This compound is the potassium salt of the ethylic ether of dithiocarbonic acid, OHCSSH.

**Preparation.**—By acting with an excess of carbon disulphide on absolute alcohol saturated with caustic potash. The crystals of xanthogenate of potassium formed abundantly are washed with ether.

**Properties.**—Xanthogenate or ethyl sulphocarbonate of potassium forms colourless or slightly yellowish needles; they are soluble in water, likewise dissolving in 5—6 parts of absolute alcohol. The decomposition of the aqueous solutions into carbon disulphide, ethyl alcohol, and potash begins at a temperature of 25° C. (77° F.), to be completed on boiling. Xanthogenate of potassium stops fermentation like carbon disulphide and coagulates albumen. Schwartz found that the action of its solutions on bacteria and ferments do not commence except at the temperature at which this salt decomposes, and that it only therefore possesses the disinfectant action of carbon disulphide. But this does not in any way detract from its valuable properties as an antiseptic, since carbon disulphide acts on bacteria in aqueous solution at 0·5 per cent. and that this product contains 47 per cent. of carbon disulphide.

**Use.**—Xanthogenate of potassium may be used in all cases where carbon disulphide and sulphocarbonate of potash have been found useful. Its solubility in water is greater than that of carbon disulphide and its stability in air more perfect than that of sulphocarbonate of potassium. Its properties would have assured it a much higher place in agricultural medicine if its price were not higher than similar compounds. Yet in spite of its high price xanthogenate of potassium is used in disinfection and enters into the composition of certain insecticides.

*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—Dr. Koenig, director of the Agronomical Station of Nice, has made very extended trials of the action of this salt on phylloxera, and found that compared with carbon disulphide and sulphocarbonate of potash its value as a disinfectant of phylloxera-infected vines was greater and more certain. The eggs and phylloxeras are killed without exception by submitting them to the action of solutions of xanthogenate of potassium or to that of the vapours which its solutions emit on heating. To disinfect the roots Koenig recommends the use of aqueous solutions.

*Schizoneura lanigera*, Hausm. (woolly aphis).—Muhlberg recommends to combat the woolly aphis an insecticide which contains two most active substances, nitrobenzene and xanthogenate of potassium. Amyl alcohol 60 lb., soft soap 40 lb., nitrobenzene 2 lb., xanthogenate 1 lb., water 6 gallons. Knadolin in 2 per cent. solution kills the greater number of insects injurious to plants. To apply it the wounds and cankers caused by the American woolly aphis are coated with a solution of 1 part of this insecticide in 15 parts of water.

**Potassium Cyanide,** KCN.—**Preparation.**—An alkaline cyanide is formed each time that carbon and nitrogen come in contact at a high temperature with an alkali or an alkaline carbonate. Commercially potassium cyanide is prepared by submitting nitrogen or organic bodies rich in nitrogen to the action of carbon impregnated with potash and heated to redness. Prussic acid or hydrocyanic acid is generated by the action of an acid on potassium cyanide.[1] The latter, however, does not give up all the hydrocyanic acid which it contains.

**Properties.**—Potassium cyanide crystallises in deliquescent cubes; it is found in commerce as fused white plates which must be kept out of contact with air because that decomposes it rapidly into hydrocyanic acid and carbonate of potash—

$$2KCN + H_2O + CO_2 = K_2CO_3 + 2HCN.$$

The commercial product is never pure, it always contains a greater or less amount of carbonate of potash. Prussic acid is a colourless, very volatile liquid having the odour of bitter almonds. It is, like its salts, a deadly poison. The vapours given off by decomposition in contact with air kill the insects and animals which breathe it in a few minutes. Its action is the same in whichever way it be introduced into the body, by digestion, respiration, or introduced into the blood through a wound. A drop of hydrocyanic acid placed on the eye of a dog causes it to die in a few seconds a dreadful death. The respiration of the vapours of this acid induce giddiness, then death. The mortal dose for a man is 0·06 gramme, say 1 grain, of prussic acid and 0·15 gramme, say $2\frac{1}{4}$ grains, of potassium cyanide. According to Preyer, prussic acid acts through the compounds which it forms with the hæmoglobin and the oxyhæmoglobin of the blood.

**Action on Plants.**—All cyanogen compounds have a poisonous action on plants, but it is prussic acid which possesses this property in the highest degree. As far back as 1827, Goppert remarked that prussic acid prevented the germination of grain, and absorbed by the plant it killed it in one to three days. When a plant is watered with a dilute solution of cyanide the latter is absorbed and distributed throughout all parts of the plant by the sap; the leaves turn yellow, then brown, and the turgescence of the cells of the parenchyma is abolished. Perosino succeeded in injecting a very dilute solution of potassium cyanide into the trunk of a tree without hurting it, and after two days all trace of this product had disappeared in the sap, but the dose to be withstood was, it is true, infinitesimal. Berlese has shown that trees withstand these injections badly, even in small doses. Mouillefert made a very complete examination of the action of potassium cyanide on vines and adventitious plants.

*Experiments made in July on Healthy Vines, variety Saint Emilion.*—Placed in pots, each containing 3 litres of soil, three vine stocks were watered with (1) 170 milligrammes of cyanide, say a 0·142 per cent. solution; (2) 250 milligrammes of cyanide in 140 cubic centimetres of water, say a 0·18 per cent. solution; (3) 500 milligrammes of cyanide dissolved in 180 cubic centimetres of water, say a 0·28 per cent. solution. In six days vine No. 3 was dead, that carrying No. 2 was greatly inconvenienced, and No. 1 seemed to suffer. As will be seen from these results the substance is highly poisonous to the vine, as a dose of 0·008 per cent. of potassium cyanide in the soil kills this plant. Guerrieri estimates that a dose of 1 gramme suffices to kill an adult vine, and that it is impossible to kill the phylloxera by this method, the vine being as sensitive as the parasite. The fact that the phylloxeras of a vine treated with cyanide die mainly by the absorption of the poisoned juice, shows that this method of treatment must be as pernicious to the vine as to the phylloxera; Chittenden considers that it is impossible to treat all plants by hydrocyanic acid vapours to free them from pests; the acid may, however, be used without fear on *Davallia, Adiantum, Coleus, Viola, Rosa, Dianthus, Vitis,* and *Lycopersicum.* It is necessary to try each variety of plants to see if this method of treatment can be successfully adopted against the caterpillars without risk to the plants themselves.

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[1] See also Sodium Cyanide, above, p. 119.

*Experiments made in July on Adventitious Plants.*—The experimental ground was a square with side of 50 centimetres and contained young plants about fifteen days old (*Mercurialis annua, Polygonum aviculare, Amaranthus blitum, Borago officinalis,* and *Erodium cicutarium*); 500 milligrammes of potassium cyanide, dissolved in 400 cubic centimetres of water, say a solution of 0·125 per cent., was distributed in five deep holes of 15—20 centimetres. In the morning all the young plants were dead. After six days nothing remained alive but two stocks of *Borago* and one stock of *Erodium.*

**Action on Fungi.**—Few trials have been made. Hitchcock and Carleton immersed the uredospores of *Puccinia graminis* in a 0·1 per cent. and a 0·01 per cent. solution. The first solution prevented germination. The second had no effect.

**Action on Insects.**—Potassium cyanide, also the prussic acid given off from it in moist air, are insecticides of extraordinary power, an infinitesimal dose killing insects in a few minutes. Its action is more energetic than that of sulphocarbonate of potash, sulphuretted hydrogen, and ammonia. It acts on insects by respiration and through the stomach. Entomologists use it to kill the insects which they catch. Mouillefert submitted different insects to the action of this poison, especially the phylloxera, which he specially examined. One gramme of potassium cyanide was placed in a 250 cubic centimetre flask. The following are the results obtained with the different insects introduced successively into the flask: A butterfly died in four minutes; a dragonfly in ten minutes; an earwig in ten minutes; a plant louse is killed in less than two minutes; a stag beetle in four minutes; and a grasshopper in less than two minutes.

In America potassium cyanide is a specific for the destruction of certain plant lice; it is to be observed, however, that their eggs withstand doses usually sufficient to kill the adult insects. According to Coquillet it is chiefly the *Diaspines,* amongst which must be counted *Aspidiotes, Diaspis, Lecanium, Ceroplastes, Coccides,* which are most sensitive to prussic acid. Whilst almost all insects succumb when they respire a weak dose of prussic acid, there are some which are indifferent to this poisonous gas: these are certain *Coccinella,* the red spider (*Acarus telarius*) of Linneus (*Tetranychus telarius,* L.); the *Schizoneura lanigera,* Hausm. (woolly aphis); and some flies of the family of *Proctotrupidæ* of the genus *Alaptus.* The danger of the prussic acid treatment is an obstacle to its becoming general, the more so as there are less dangerous substances, which, in the same conditions, are of equal service. There are, however, certain cases where prussic acid is superior to these products. When it is a question of destroying one of those plant lice covered with a chitinous carapace, ordinary insecticides which do not reach the insect must be set aside, for that reason. Emulsions of petroleum, amyl alcohol, benzine, and carbon disulphide, with soft soap, only yield imperfect results. It is otherwise with prussic acid; its vapours, owing to their poisonous nature, can destroy the best protected insects through the respiratory organs, and as easy as any soft-skinned insect. In America the benefits of the substance have been recognized, and it is in constant use by farmers. By means of potassium cyanide used rationally in winter, fruit trees may be freed from all their parasites. In America apple-trees have been particularly the prey of the San José louse, but potassium cyanide, which has played in this case the *rôle* of carbon disulphide in the phylloxera invasion, has enabled this dangerous insect to be efficiently combated.

**Use.**—In spite of its toxicity and the danger incidental to its use, potassium cyanide is in current use in certain countries; it is, in fact, the most radical and the cheapest means to destroy tree parasites. Cyanide can only be used in a closed space. Its decomposition is hastened by the addition of dilute sulphuric acid. This practice requires great precautions, because the prussic acid given off is as deadly to the operator as to the insects. When a greenhouse is not at disposal the operation is done under cloches for small plants, and under tents for trees. The latter are of packing cloth, impregnated with linseed oil and ochre, or wax. These portable tents are generally hexagonal in shape and must touch the ground on all sides; they are closed hermetically by beating down the soil on the edges of the cloth. In America they use exclusively large cubes with a wooden framework covered with packing cloth. In this manner trees as high as 20 feet may be treated. To disinfect a tree the tent is placed over it, and then a solution of potassium cyanide is run into a terrine to which dilute sulphuric acid is added, taking care to place this terrine quickly under the tent and to retire. The following, according to Debray, are the quantities to use for 5 cubic metres of air: 30 grammes of 58 per cent. potassium cyanide dissolved in 50 cubic centimetres of water, 35 grammes of sulphuric acid of 66° Bé. (168° Tw.) diluted with 50 cubic centimetres of water. According to Coquelin, the doses of potassium cyanide to use according to the size of the tree are as follow:—

TABLE XIX.—*Showing the Amount of Potassium Cyanide, Water, and Sulphuric Acid to Use in Cyaniding Trees of Different Height and Diameter.*

| Height. | | Diameter. | | Potassium. | | Water. c.c. | Sulphuric acid. | |
|---|---|---|---|---|---|---|---|---|
| Metres. | Feet. | Metres. | Feet. | Grammes. | Grains. | | Grammes. | Oz. Av. |
| 3 | 9·84 | 2·50 | 8·20 | 65 | 997 | 130 | 65 | 2·3 |
| 3·50 | 10·48 | 3·00 | 9·84 | 130 | 1994 | 250 | 130 | 4·5 |
| 3·50 | 10·48 | 4·50 | 14·76 | 250 | 3835 | 500 | 250 | 8·7 |
| 4·25 | 13·94 | 3·00 | 9·84 | 160 | 2454 | 350 | 160 | |
| 4·25 | 13·94 | 3·50 | 10·48 | 210 | 3222 | 500 | 210 | |
| 4·75 | 15·58 | 4·25 | 13·94 | 340 | 5216 | 750 | 340 | |
| 5·50 | 17·08 | 4·25 | 13·94 | 425 | 6521 | 850 | 425 | |

The action is complete in a quarter of an hour (Debray), three-quarters of an hour (Ritzema Bos), and five hours to destroy kermes (Reh). Johnson says that disinfection is complete in a very short time, and that with ten apparatus, 200 trees may be disinfected in a day, the operation lasting half an hour. A method much in vogue in American consists in disinfecting the roots of young nursery plants as far as the crown. For this purpose all the trees are dug up, and placed in closed cupboards or chambers in which prussic acid is disengaged; 10,000 young trees can be disinfected in this way at a time. Dr. Koenig has introduced the practice of this style of disinfection at the Agronomical Station of Nice, where it is employed for vines, ornamental plants, as well as the branches of ornamental plants intended for exportation. Waite and Howard recommend for the disinfection of purchased trees hermetically sealed cupboards, in which they are enclosed for an hour in an atmosphere of prussic acid before replanting; although the majority of plants resist the action of these poisonous vapours it is preferable to operate during the repose of vegetation, for in that condition they resist stronger doses capable of destroying the parasites and their eggs. The action may be prolonged, and even last an hour. The result is only the more complete. Tuille recommends for the destruction of the larvæ of the cockchafer (*Melolontha vulgaris*, L.) to plough in colza or mustard during the flowering season along with a ton of gypsum or lime per hectare (8 cwt. per acre). Amongst the poisonous gases given off in consequence of the fermentation of these plants is sulphuretted hydrogen, but also a certain amount of prussic acid.

*Scolytides.*—In America prussic acid is regarded as an excellent substance for destroying the insects which dig galleries in the trunks of trees. It may be applied at the moment the *Scolytides* or the *Bostriches* attack the young trees.

*Wasps.*—Gardner recommends the use of a solution of 120 grammes in a litre of water (1·2 lb. per gallon). A plug of waste is attached to a rod dipped in this solution, then introduced into the orifice of the nest of wasps. The effect is instantaneous.

*Ptereneus ribesii*, Scop. (gooseberry saw-fly).—The highly voracious larvæ of this saw-fly are destroyed in Canada by cyaniding, working under small tents as already mentioned. The gas acts in fifteen minutes. To destroy the butterflies injurious to cotton plantations, Mally plants haricot beans between the rows. As soon as the latter are in flower they are sprayed with a dilute solution of potassium cyanide. That kills the butterflies which settle on the flowers.

*Carpocapsa pomonella* (the codlin moth).—It is in winter that fumigation under a tent with prussic acid may be very effectual. The process is in common use in Canada.

*Diplosis violicola*, Coquillet (violet fly).—Chittenden advises treating the violet stocks with potassium cyanide, so as to kill the larvæ of this fly.

*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—*Experiments on the phylloxera action by contact.*—A phylloxera-infected root was immersed for two minutes in a 1 per cent. solution of potassium cyanide; the phylloxeras and their eggs were all dead when it was lifted out.

*Experiments on Phylloxera: Fumigation.*—Five milligrammes of potassium cyanide, yielding by decomposition 1·7 cubic centimetres of prussic acid vapour, were placed in a flask of 2100 cubic centimetres, then a phylloxera-infected root. When the action was complete the atmosphere of the flask consisted of 8 parts of prussic acid vapour per 10,000 parts of air. After fifteen hours there were no living insects. It follows that potassium cyanide is about ten times more poisonous than potassium sulphocarbonate, for it suffices for an atmosphere to contain 0·08 per cent. prussic acid gas to obtain the same result as with 0·75 of a mixture of equal parts of sulphuretted hydrogen and carbon disulphide, disengaged from potassium sulphocarbonate. Under a cloche 0·000240 of potassium cyanide kills plant lice.

*Experiments on Phylloxera: Action by Poisoning.*—A phylloxera-infested root was immersed by its extremities in a 0·125 per cent. solution of potassium cyanide with the precautions necessary to hinder the phylloxera being exposed to prussic acid vapours. After ten minutes' treatment the adult phylloxera, the nests of which were sunk in the tissues of the root, were dead, the greater number of the larvæ were alive. The cyanide can thus poison the sap, and in that way reach the phylloxeras fixed on the roots. Mouillefert having shown that potassium cyanide acted in a very poisonous manner on the phylloxera, and that an infinite quantity killed these insects either by contact or by poisoning the sap, the substance may be regarded as of great service in agriculture.

1. *Experiments on Phylloxera-infected Vines*, in pots containing 3 litres of earth, on 10 July. A dose of 150 milligrammes of KCN in 400 cubic centimetres of water (a 0·0375 per cent. solution) gave a complete result without injuring the vine, whilst a dose of 500 milligrammes in 500 cubic centimetres water caused it to suffer greatly. A dose of 1 gramme in the same amount of water killed it.

2. *Experiments on Vines in Vineyards*, made on 6 July. The stocks were stripped to a depth of about 15 centimetres, with a radius of 30—35 centimetres (12—14 inches), the soil being rather dry. After pouring on the potassium cyanide solution the soil was replaced at the foot of the stocks and strongly packed. The dose used varied from 20—50 grammes (307—767 grains) per stock, dissolved in 10 litres (2·2 gallons) of water. Wherever the solution had penetrated, the phylloxera and their eggs were dead. But at a depth of 40—50 centimetres (16—18 inches), as well as between the stocks in a radial direction, even by using five times more water the result was incomplete. Trials with the injection method gave no better results, and Mouillefert concluded that potassium cyanide was incapable of producing a complete result in agriculture on the large scale, because its action is only felt where the solution can penetrate. The prussic acid disengaged in the soil cannot diffuse through its layers like carbon disulphide, neither does F. Guerreri believe it possible to use this substance against the phylloxera, for he found that the plant did not resist the doses required to kill it, and that a dose of 1 gramme of cyanide, say 15 grains, per stock was capable of injuring it. Attempts to replace carbon disulphide by potassium cyanide, more especially in Italy, have given unfavourable results.

**Disinfection of the Vine.**—Whilst potassium cyanide has been abandoned in the different cases described above, this product is used with success to disinfect vines intended for exportation, or coming from a contaminated country. This process, introduced at the Nice Agronomical Station by Koenig, yields perfect results. It is in common use, moreover, in Tuscany. Sannino advises replacing the disinfectant chambers by baths containing a 0·5 per cent. solution, and in which the vines are immersed in winter for two hours. The same process is used to destroy coccides on fruit trees.

*Diaspines* (*Diaspineæ*).—Coquillet uses prussic acid as a specific against *Diaspineæ*, coccides (scale insects).

This product may be used against all these dangerous parasites, of which the following are the chief: *Aspidiotus perniciosus*, Comstock (San José louse), injurious to apple-trees in America. *Aspidiotus ostreaformis*, Curtis. Oyster scale, very widely distributed on apple-trees, plum-trees, pear-trees, and peach-trees. *Aspidiotus aurantii*, Maskell. Coccis injurious to orange-trees. *Diaspis ostreaformis, sign. s. fallax*, Horvath. Coccis injurious to apple, pear, plum, and peach trees. *Mytilaspis pomorum*, Beché. Mussel scale, resembling the preceding and living on same plants. *Lecanium persicæ* (peach kermes); *Lecanium hesperidium* (olive kermes); *Pulvinaria vitis* (vine coccis); *Cereplastes rusci* (fig coccis); *Dactylopius citri* (lemon-tree coccis); *Lecanium amygdali* (almond-tree coccis). American entomologists are unanimous in praising the good effects of the use of potassium cyanide, and that insecticide is in current use in their country. So that the result may be complete, the treatment should last three-quarters of an hour, and the operation done in winter as indicated above.

Earth-worms are less resistant than plants to spraying with a dilute solution of potassium cyanide and they may be got rid of by this means.

Small pieces of potassium or sodium cyanide may be pushed into the holes bored in trees by the larva of the goat moth, the holes being then plugged with clay.

The British Ministry of Agriculture recommends that an article sold as potassium cyanide for agricultural and horticultural purposes should be capable of evolving (when treated with an acid) not less than 39·4 per cent. of its weight as hydrocyanic acid.

Against soft scale (*Coccus hesperidum*, L)., which infests a wide range of fruit trees in S. Africa, the most satisfactory remedial measure is fumigation with hydrocyanic acid gas; other measures are contact insecticides, such as resin wash or miscible oils, and a soap wash consisting of 1 lb. of soft or hard soap and 8 gallons of water. This should be applied warm.

At Porto Rico considerable time has been spent by the entomologist in fumigating tobacco warehouses and factories with hydrocyanic acid gas against *Lasioderma serricorne*, fully 4,750,000 cubic feet of space being treated. The warehouses were treated with 40 oz. of sodium cyanide per 1000 cubic feet for forty-eight hours. As a result there has been a considerable reduction in the loss caused by this beetle in cigars.

In the U.S.A. serious complaints have been made by nurserymen and owners of orchards relative to injury to nursery trees when fumigated with hydrocyanic acid gas, and of the factors involved. Nearly all admit the effectiveness of the fumigation in destroying scale-insects. It was probably harmless to trees that were perfectly dry at the time of treatment, but it was found impossible always to have the trees in the right condition for fumigation.

*Fumigation of Ships.*—In a paper read before the London section of the Society of Chemical Industry Dr. Monier-Williams gave an account of experience gained during two years in the fumigation of ships for the purpose of destroying rats and vermin, with hydrogen cyanide (prussic acid gas). He pointed out that poisoning and trapping can never account for the whole of the rats on a ship, whereas fumigating, if properly carried out, can do so. In the past, sulphur dioxide had largely been used, but the United States Quarantine Regulations of 1920 required all vessels engaged in trade with foreign ports to be fumigated every six months. This necessitated the fumigation of the passenger quarters of Transatlantic liners, for which purpose sulphur dioxide could not be used, owing to its corrosive action on furnishings and decorations. Hydrogen cyanide was first used in 1890 in the orange orchards of California and Florida; in 1898 it was used by the Cape Government Railways for bugs and lice in sleeping carriages; it was used in India by Col. Glen-Lister in 1899 and in quarantine work in Porto Rico in 1910. Since the war, the use of HCN became general, especially in American, Australian, and Italian ports. Discussing the properties of hydrogen cyanide, Dr. Monier-Williams said that the toxicity of it is not so great as was formerly imagined, and possibly 1 part in 10,000 of air, or even a higher concentration, could be breathed with impunity. At the same time, beyond 1 part in 2000 of air its action was rapid, and 1 in 500 would probably kill a man instantly. HCN, however, is not an irritant. There was not much smell and the critical point is not easy to recognize. Thus the precautions necessary were more elaborate than with $SO_2$, and the great essential of fumigating by this method is the most careful organization of the work. The various methods by which HCN can be used were described, the simplest being to place tubs in various parts of the ship containing 1½ parts by weight of sulphuric acid to 1 part of water, and to hinge, on the sides of the tubs, boxes containing solid cyanide, these boxes being tipped up by means of a cord, so that their contents fall into the tubs and so cause the liberation of HCN. Accidents have occurred in foreign ports by the use of HCN, but mostly through negligence in adopting the most ordinary precautions. Among other methods is a solution method in which the cyanide is previously dissolved in water and the solution poured through funnels on deck through rubber hose pipes leading to the tubs below, and on the whole it was suggested that this is preferable.

**Potassium Sulphocyanide,** KCNS.—**Preparation.**—Sulphocyanides are produced by the action of sulphur, or a body capable of producing sulphur, on cyanides. Potassium cyanide, or even yellow prussiate, fused with sulphur is converted into potassium sulphocyanide thus: 46 grammes of yellow prussiate are heated to pasty fusion with 17 grammes of potash and 32 grammes of sulphur; after cooling, the mass is crushed, treated with boiling alcohol, filtered, and evaporated.

**Properties.**—If sulphocyanide has certain analogies with cyanide it is far from being as poisonous. It paralyses the action of the heart (Cl. Bernard and Pelikan).

**Action on Plants.**—Mouillefert treated several plants with KCNS :—

(1) *Experiments on Adventitious Plant Weeds.*—In a space 16 inches square on which there were young plants of *Mercurialis annua, Amaranthus blitum, Senecio vulgaris, Sonchus oleraceus, Polygonum aviculare*, Mouillefert placed in six holes, 6 grammes, say 91 grains, of KCNS, dissolved in a litre of water (6 parts in 1000). Next morning all the young plants were dead. The adult plants had suffered greatly.

(2) *Experiments on Healthy Vines in Pot.*—Half a gramme of KCNS in 250 cubic centimetres of water (1 in 500) and spread round the stock killed it in five days. KCNS thus has a very injurious action on plants, an action almost equal to potassium cyanide. As it does not act by its vapours, its action on the plant depends solely on the permeability of the soil for its solutions. This explains why equal doses do not always produce identical effects. The same applies to aqueous solutions of all stable salts. Kranch treated barley with $(NH_4)CNS$, and found that a 1 per cent. solution killed this plant.

**Action on Fungi.**—Sulphocyanides do not act like cyanides (Hitchcock and Carleton). A 1 per cent. solution used in immersion for twenty-four hours did not prevent the uredospores of *Puccinia coronata* from germinating.

**Action on Insects.**—Mouillefert treated phylloxera-infected vines with a dilute solution of KCNS. An infected pot plant was watered with the dose recognized as capable of killing the vine, say 0·5 gramme, dissolved in 250 cubic centimetres of water. Whilst the vine was poisoned the phylloxera were uninjured. Sulphocyanide, very energetic on plants, is thus with the same dose without action on the phylloxera and cannot be used against it.

# CHAPTER VIII

BARIUM CHLORIDE—BARIUM SULPHATE—BARIUM CARBONATE—BARIUM SULPHOCARBONATE—CALCIUM OXIDE (QUICKLIME)—CALCIUM SULPHIDE—CALCIUM CHLORIDE—CALCIUM CHLORO-HYPOCHLORITE (BLEACHING POWDER)—CALCIUM SULPHATE (GYPSUM, PLASTER OF PARIS)—CALCIUM SULPHITE—CALCIUM CARBIDE—CALCIUM PHOSPHIDE—CALCIUM ARSENITE—CALCIUM ARSENATE—CALCIUM CYANIDE.

**Barium Chloride,** $BaCl_2$.—**Preparation.**—By treating barium carbonate (Witherite) with dilute hydrochloric acid. Carbonic acid is given off and barium chloride crystallized as small rhomboidal lamella formed with two molecules of water of crystallization.

**Properties.**—Barium chloride is soluble in water; 10 gallons of water dissolve 45 lb. at 15° C. Its taste is sharp. It is so poisonous that 4—5 grammes, say 60—75 grains, according to Parkes, kill a man, on whom it first induces general weakness, then paralysis.

**Action of Barium Chloride on Plants.**—When plants are watered with barium chloride in 0·05—0·5 per cent. solution, chlorosis is induced and lesions occur on the roots. This action is more pronounced the younger the plant, and likewise varies with the nature of the plant. Barium chloride behaves like common salt and like carbonate of lime.

**Action on Insects.**—It appears to be very poisonous to insects. Absorbed with food this salt kills them as rapidly as arsenical preparations.

**Use against Plant Diseases.**—Maravek recommends 2 per cent. solutions to kill injurious insects. G. Staes uses it with success against the ravagers of young beets, and especially against the altises which sometimes completely devour the young leaves. Young plants support a few days after sprouting a 2 per cent. solution of $BaCl_2$, and when in leaf a 3 per cent. solution. Three sprayings kill coleopterous parasites. Mokezecki recommends spraying with $BaCl_2$ to destroy the grub of the following ravagers: *Anisopterix æscularia*, Schiff.; *Hibernia marginaria*, Bk.; *H. defoliaria*, *Cheimatobia brumata*, L.; *Uropus ulmi*, *Himera pennaria*, *Phlacetonodes sticticalis*, and *Hyponomeuta malinella*, Zell. They recommend the use of this salt according to circumstances in 1½ to 2—3 per cent. solution, adding 12 per cent. of sodium carbonate to give adherence to the liquor by the resulting barium carbonate. The action of this product on the grubs makes itself felt after four hours, whilst emerald green under similar conditions requires twenty-four hours to act. This poison, very deadly to grubs and insects, would appear to be harmless to the plants treated, for neither the leaves nor the fruit appear to suffer in contact. It is, however, costly and very poisonous; it must, therefore, be used with great caution, especially on meadows used as pasture for domestic animals.

*Weevils.*[1]—Still recommends $BaCl_2$ to kill them.

*Peritelus griseus* (vine weevil).—Stromer remarks its presence on the hop, and recommends spraying with $BaCl_2$ solutions to kill it.

*Phorodon humili*, Schrank (hop aphis, green-fly).—Metzger kills this louse by spraying with 1 per cent. solutions of $BaCl_2$. The results obtained have been very satisfactory, and he regards this salt as more efficacious than extracts of quassia. As aqueous solutions of $BaCl_2$ want adhesiveness, Metzger recommends a paste of 2 per cent. of barium chloride and 1·5 per cent. of soft soap. Eight days after treatment the aphides had entirely disappeared.

Against *Ptereneus ribesii* successful spraying has been done with a 2 per cent. solution of barium chloride. The addition of 1 per cent. of lime was found convenient to indicate the area treated.

Poison-baits are very effective against millipede, *Blaniulus guttatus*, Gerv., if the bait is pieces of potato previously soaked for half an hour in a 5 per cent. solution of barium chloride or in a ½ per cent. solution of arsenic.

*Rodents.*—Barium chloride acts on rodents like carbonate of baryta. To exterminate them Hilner places bread dipped in barium chloride in their runs.

**Barium Carbonate,** $BaCO_3$.—**Preparation.**—By precipitating solutions of barium chloride by carbonate of soda. The natural carbonate (Witherite) is not used as such.

**Properties.**—Poisonous, insoluble in water.

**Use.**—Largely as poison for the rodents which ravage cultivated land. One pound of bread is mixed with ¾ oz. of sugar and ¼ lb. of precipitated carbonate of baryta; the mass is kneaded and then divided into about 2000 pills (Ressler). One lb. of barley meal is kneaded with ¼ lb. carbonate of baryta and the amount of water necessary to make a stiff paste and divided into pills and laid in their runs (Crampe).

**Barium Sulphocarbonate,** $BaCS_3$.—**Preparation.**—By treating a concentrated solution of barium monosulphide by carbon disulphide, solid barium sulphocarbonate is deposited.

**Properties.**—Barium sulphocarbonate is a yellow salt slightly soluble in water and resists the action of the carbonic acid of the air for some time; it is more stable than alkaline sulphocarbonates, but it is equally poisonous to plants, and has equal powers as an insecticide.

**Use.**—*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—Mouillefert examined its effect compared with alkaline sulphocarbonates. Two vines were stripped down to the large roots and treated with 75 grammes (2½ oz.) of barium sulphocarbonate; the first was not watered in any way, whilst the second was immediately watered with 6·5 litres of water, say 1½ gallons. With the latter the result was perfect, whilst on the roots of the first a large number of undestroyed parasites were found. Barium sulphocarbonate exists a long time in the soil without decomposition, and if not dissolved by heavy rain its action is too slow, and is not transmitted to the deep roots. The latter are not therefore surrounded by a sufficiently poisonous atmosphere to kill the phylloxera and the results are bad.

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[1] Curculionides (weevils).—Coleoptera characterized by a prolongation of the interior part of the head called the beak or rostrum; the form of the body is bomb-shaped, for the elytra always surround the lower part of the abdomen. The larvæ are polyphagous, they live in the interior of the vegetable tissues (fruits, roots, stems, buds, seeds).

**Calcium Oxide (Quicklime).** $CaO$.—**Occurrence.**—Widely in nature; chiefly as carbonate, sulphate, silicate, and phosphate of lime.

**Preparation.**—Quicklime may be made from carbonate of lime, either in the pure state as marble or chalk, or impure as marl or limestone. Limestone is burnt in lime kilns by heating it gradually to a red heat. This heat, kept up for three days on an average, decomposes the limestone into quicklime and carbonic acid.

$$CaCO_3 = CaO + CO_2.$$

As soon as the burning is finished and the mass cooled, it is packed in casks, and hermetically sealed so that the air does not affect it by its carbonic acid and moisture.

**Properties.**—Lime is converted by the action of water into hydrate of lime ($CaOH_2$) or slaked lime. In slaking, the lime gives off much heat and swells or increases in bulk. In contact with carbonic acid calcium hydrate is converted into calcium carbonate ($CaCO_3$). Milk of lime exposed to the air does not keep more than two to three months, and gradually loses its caustic properties. Lime is very slightly soluble in water, which only dissolves at the ordinary temperature 0·14 per cent.; hot water only dissolves 0·1 per cent. Lime stirred up with water remains suspended, and forms a milky liquid, "milk of lime." This milk is the fatter, the more pure the lime from which it is made. There are two sorts of lime, fat lime and thin lime. The first comes from the burning of almost pure limestone, such as chalk or marble; it is white, and gives off much heat on slaking and increases two or three times in bulk; it forms with water a fatty and binding paste. Thin lime, on the other hand, is produced by the impure limestones referred to above; it is grey, and disengages little heat on slaking; mixed with water it hardly swells and forms a short paste. For agricultural purposes, and particularly for agricultural medicine, it is necessary to choose a fat lime, which yields on slaking a very caustic impalpable powder, which, stirred up with water, yields a milk with great adherence. To increase this still more, a little cement, bullocks' blood, potters' clay, or cow dung is added. The white colour, often too glaring, is subdued by stirring a little lampblack into the milk of lime.

**Action on Plants.**—Milk of lime is a strongly alkaline product which behaves to plants like alkaline liquids, that is to say, it injures the young buds but is without action on the adult organs. Cellulose is not attacked by lime, so milk of lime may be used with impunity in spraying on the different parts of adult plants, and the strength of this milk of lime may be increased at will. There are, however, some exceptions. Sorrel, for example, does not stand its action; the same applies to mosses and lichens, the growth of which requires much moisture, are quickly destroyed by lime and especially by quicklime.

**Use against Fungi.**—Alkaline substances have a decided but weak action on fungi spores. This property was utilized in the beginning of last century to destroy the spores of smut and bunt; at that time no substance fit to render the same service was yet known, and lime was officially recommended by the (French) Government although it had not given very complete results. The chief advantage was that the method did not injure the seed. However, Phillipar found that after this process had been applied, and although all the grains were uniformly covered with lime, the resultant crops still gave 260 bad ears per 1000. Girardin likewise found 112 bad ears per 1000 after macerating the seeds for twenty-four hours in 1 per cent. milk of lime. Loverdo believes that this bad result is due to the cellulose nature of the exospore of the *Ustilagineæ* which opposes a resistance to the alkaline action of lime. According to tests by Kuhn the spores of the bunt of wheat, *Tilletia caries*, resist milk of lime for five hours, but after twelve hours' immersion they have lost their vitality. Bolley does not believe in lime as a disinfectant. Slaked lime in powder had no appreciable action, but immersion for twenty-four hours in a milk of lime gave a result especially on addition of a certain amount of common salt. The following, according to Mathieu de Dombasle, is the comparative result of this treatment (bad ears in 1000) carried out in various ways: Blank wheat, 486. Wheat covered with lime powder, 476. Wheat moistened with milk of lime, 260. Wheat immersed for twenty-four hours in milk of lime, 21. Wheat immersed for twenty-four hours in milk of lime of 2·5 per cent. strength and 4 per cent. common salt, 2. The effect of lime is thus very perceptible, but as soon as common salt or sulphate of soda is added the effects are much more complete. Lime is not now used alone to disinfect cereal grains, but is an indispensable aid to this treatment. Its chief *rôle* is to neutralize the disastrous effects of the poisonous salts on the germinative capacity of the seed and to fix the anticryptogamic products in an insoluble form on the surface of the seeds. By treating with milk of lime seeds which have been steeped in a solution of blue vitriol, the action of which is very injurious to the vitality of the seeds, this salt is converted into copper hydrate. The latter, mixed with sulphate of lime, forms round the grains a deposit of preservative matter, so little soluble as not to be washed away by the water in the soil and capable of preventing the germination of the spores adherent to the surface of the grain as well as the invasion of filaments of bunt which might be present in the soil. The spores of *Phytophthora infestans*, de By. (potato disease) resist milk of lime; the latter is incapable of arresting the development of that disease. Rust of wheat likewise resists the action of lime even in heavy doses and in mixing it with equal parts of sulphur.

Hitchcock and Carleton have, however, found that lime paralysed the growth of the uredospores of *Puccinia rubigo vera*, Wint. (rust of wheat). But lime has no effect on *Hypomyces perniciosus*, Magnus, mole disease of the mushroom. Used to combat the *Guignardia Bidwelli*, Viala et Ravaz (black rot of the vine), lime gives fairly good results. Galloway obtained by this method an appreciable diminution of bad seed: on the untreated plot 45 per cent. of diseased seed, on the limed plot only 20 per cent. of damaged grain. Debray also regards the liming of the vine as a cure for *Gloesporium ampelophagum*, Sacc.

(grape rot), *Botrytis cinerea*,[1] Pers. (the noble or grey rot of the vine). Sorauer advises to spread quicklime on the grapes in autumn as soon as this mould appears.

*Gummosis of Stone Fruit Trees.*[2]—Sorauer advises liming the ground strongly around the trees attacked by this disease so as to render the soil drier and warmer, an essential condition in counteracting this disease. Wiesner regards this diseased condition of the trees as due to the development of a special ferment, a species of diastase. Be that as it may, a good result is obtained by spreading lime in the autumn at the foot of the trees. If the trees in a moist soil suffer from canker or rot of the roots, the roots must be stripped, lime spread between them, and the soil drained. This treatment leads to a perceptible improvement in the diseased condition of the tree.

*Rhizoctinia violacea*, Tul. (rhizoctinia of the beet).—Frankel recommends to spread slaked lime in powder on the fields to diminish the number of parasites. Here again lime only acts directly as on mushrooms by changing the conditions favourable to their development; it arrests their growth and imparts to the plant by converting the humus into assimilable matter the capacity to resist disease better. Unfortunately it is alleged that lime, whilst it diminishes the amount of these parasites, favours the development of other and not less formidable beet diseases, *e.g.*, *Phoma tabifica*, Prill. and Dela. (disease of the petioles of beet leaves). The alkalinity of the medium in a wet soil exerts a generally favourable influence on the development of the bacterian diseases of plants. Some authorities regard lime as favouring potato scab considerably. To reduce these diseases it is on the contrary useful to render the medium acid, say by green vitriol or by "sulpharine," which contains 15 per cent. sulphuric acid.

*Ophiobolus graminis*,[3] Sacc. (*Pietin*), (disease of wheat stalk).—Sance advises as a cure to sow by hand 176 lb. of quicklime per acre as soon as the disease appears. Marenghi recommends quicklime as a preventive; he advises to spread 3—4 cwt. per acre and to harrow the ground slightly afterwards.

*Tobacco Leaf Spot.*—Van Os, to prevent this disease, ploughs in

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[1] BOTRYTIS CINEREA (grey rot of the vine). *Vine Sclerotinia.*—In a humid and warm medium this fungus, generally saprophytic, attaches itself to the leaves and the young buds of the vine; the young bunches of grapes may, likewise, be attacked at the time of flowering; but it is chiefly when the grapes are half-grown that the packed and compact grapes are destroyed by this fungus. The grapes attacked first assume a dirty tint, their surface tarnishes, they wither and become covered with a velvety grey which characterizes this disease. When the *Botrytis* develops only on ripe grapes it causes no damage; it then improves the quality of the wort. The green mould does not attack the vine alone. On a number of plants on which at the outset the stems are seen to become brown, fade, and wither without apparent cause, the medulla contains *Sclerots* which produce conidiophores of *Botrytis* covering the damaged organs with an ashy, velvety grey.

[2] GUMMOSIS OF STONE FRUIT TREES (cherry leaf spot).—The fungus *Coryneum Beyerinckii* is regarded as the chief cause of the gum of stone fruit trees, known under the name of spot of stone fruit trees.

[3] OPHIOBOLUS GRAMINIS (disease of the lower part of the stem of wheat).—Laid wheat is due to the invasion of the winter nodes nearest the soil by a fungus which, in damaging the stalk at the level of the soil, is often the cause of the laying of the straw of cereal crops. The mycelium develops in the interior and the exterior of the tissue.

11 bushels of quicklime per acre. He thus brought down the proportion of diseased plants to 7 per cent., whereas it was 100 per cent. in the unlimed plot.

*Plasmodiophora brassicæ*, Woronine (finger and toe).—Lime is an excellent means of preventing the spread of this fungus. Nijpels advises to mix the infected soil with half a litre of lime per square metre. Seltensperger applies the following treatment: During and after transplanting there is deposited at the foot of each cabbage in a sort of deep cup, of 6—10 centimetres, made for the purpose, a big handful of quicklime which is covered with earth to the level of the surface. Of 600 cabbages and cauliflowers treated thus none were attacked by the disease, whilst the untreated plot was seriously compromised; 25 per cent. of the cauliflowers and 50 per cent. of the cabbages were attacked. Halstead who advises this treatment in America believes that it has a preferable effect on plants to that of Bordeaux bouillie, corrosive sublimate, blue vitriol, kainite, but it is necessary to use at least 2 tons 8 cwt. per acre.

**Use of Lime against Nematodes.**—Lime in strong doses is a cure for these worms. Lime spread on the surface of the soil changes its characters entirely. The humus (mould) sought after by these worms being transformed the soil does not any longer present the conditions essential to their growth. The evolution of the nematodes is, moreover, arrested by the alkalinity of the soil. Although lime, and especially quicklime, may disinfect the soil and thus improve certain crops it cannot replace carbon disulphide, which according to Girard destroys more surely all the nematodes in a field.

*Heterodera Schachtii*, A. Schmidt (nematode of the beet).—Hollrung found this nematode very sensitive to the action of lime, and that by mixing 1 part of quicklime with 4—6 parts of soil these nematodes were destroyed. Kuhn advises applying the lime in autumn, as in that way whilst diminishing the number of nematodes the lime transforms the humus into assimilable matters and enables the more vigorous beet to reconstitute its radicular system attacked by the parasite.

*Tylenchus devastatrix*, Kuhn.—The liming of seed-corn is without effect against these, and disinfection does not diminish this disease, as the insects are polyphagous and even saprophytic. These insects live on the most diverse plants, causing very different diseases, chiefly on onions, clover, potatoes, poppies, etc. Weiss advises to burn the stems after harvest and dust the fields with quicklime and apply mineral manure in abundance in the springtime.

**Use against Insects.**—Few insects are sensitive to the alkaline action of lime, yet those with soft skins and delicate larvæ do not resist milk of lime or powdered quicklime, which they particularly dread. Lime thus forms an excellent medium for fighting these parasites. But in most cases lime has only a mechanical action on the spot occupied by the insect.

Perroncito's experiments on the eggs of *Bombyx mori*, L., have proved that milk of lime cannot kill the latter, for the eggs of this bombyx are capable of being perfectly hatched after steeping in milk of lime for twenty-four hours. In spite of this harmlessness, milk of lime is used in arboriculture, for the lime-washing of the trunks is an excellent method of diminishing the number of these parasites. The previous cleaning of the trunks removes all moss, lichens, and bark which formed so many refuges in which the insects and their larvæ pass the winter and eggs are laid. It plays as great a *rôle* as the liming itself. All the hiding-places preferred by these parasites are destroyed, and not knowing where to deposit their progeny they are obliged to seek refuge elsewhere. Against coccids lime exerts a special mechanical action; their shell, covered by a thick layer of lime, is, owing to the contraction of the lime, detached from the branch on which it was fixed, thus causing death.

**Liming of Trees.**—This practice advised by Blanchère is a very good one for it frees the trees well from parasites. The strength of the milk of lime may be increased to a thick paste without injuring the tree. To secure good disinfection it is better not to use milk of lime alone but mixed with tar and naphthalene as advised by Balbiani. To complete the work of liming it is well to collect and burn all the broken particles of bark and to bury with quicklime all the fallen fruit. As it slakes the lime destroys the parasites by the heat given off. By this means the number of anthonomes, cheimatobias, and even *Schizoneura lanigera* (woolly aphis) are greatly diminished. The results will be more complete the more regularly the liming is repeated.

Lime wash for fruit trees (British Ministry of Agriculture formula). Best stone quicklime 10—15 lb., water 10 gallons. Slake the lime with a little water, add the rest of the water, with thorough stirring, and strain carefully into the spraying machine.

*Scolytides.*[1]—The Bostrichi and the Hylesini, injurious to conifers, the scolytides, injurious to deciduous forest trees, cannot be destroyed by liming the trunk, but regular whitewashing with lime may remove them. Again whitewashing with thick and pliant lime in autumn after scraping the tree stops the exit orifice of the scolytides and renders the bark less accessible to the female in winter. Robert advises summer liming. If during summer a tree is badly infested by these insects there must be no hesitation in making longitudinal cuts or a surface barking, taking care immediately afterwards to coat the wound or the trunk with milk of lime. But when the tree is too far gone it is preferable to fell it and burn it, taking care to protect all the adjacent trees by liming or with the coating described further on. This operation, extensively applied in Austria, consists in painting the trunks and even the branches with a mortar made thus: Macerate 5½ lb. of tobacco in 1·1 gallons of hot water kept at a rather high heat, add 11 lb. of ox blood, and 11 lb. of lime and cow dung to a pasty consistency. The trunks and branches are coated several times with this composition until a hard weather-resisting coat is formed.

Amongst the better-known scolytides there may be quoted *Eccoptogaster pruni*,[1] Ratz. (scolytus of the plum). *E. regulosus*,[1] Koch.

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[1] Scolytides.—The scolytides are small-sized Coleoptera, which the number and nature of their depredations render very injurious to forest and fruit trees. They bore holes of various shapes, for the most part between the bark and the wood, in which the female lays its eggs. The larvæ bore secondary holes, which sometimes penetrate directly and deeply into the wood. Scolytus of the Plum. *Scolytus pruni.*—It ravages plums and apple-trees. The foliage of the invaded trees is scanty, their growth is sickly, and they do not yield fruits.

(rugose scolytus). *E. Scolytus*, Ratz. (elm scolytus). *Hylesinus oliperda* (hylesinus of the olive-tree, cirai, taragnon). *Tomicus ficus*, Er. (bostrich of the fig). *Tomicus mori*, Aub. (bostrich of the mulberry). *Bostrichus dispar* [1] (apple bark beetle), Hllw., and *B. saxesini*, Ratz., both injurious to fruit trees. All these scolytides may be removed by the above treatment.

*Colaspidema ater*,[2] Ol. (negril).—Debray recommends the liming of lucerne the moment the young larvæ commence their inevitable invasion, but, so as not to be forced to lime all the field of lucerne, it is well to mow it prematurely and only leave a small strip of lucerne where all the larvæ will take refuge; this strip is then limed.

*Anthonomus piri*, Boh. (anthonome of the pear); *A. pomorum* (apple blossom weevil).—Poubelle limes the trees in autumn with a mixture of lime 22—33 lb., flowers of sulphur 22 lb., gelatine 6·6 lb., the whole mixed with water to a thick paste which is spread on the trunks after removing the moss.

*Haltica ampelophaga*, Geur. (altise of the vine).—The green altise which ravages the leaves of the vine may be destroyed by projecting powdered lime on to the vines (Audibert).

*Crioceris asparagi*, L. (asparagus beetle).—Vial advises dusting the asparagus with impalpable slaked lime, preferably in the morning dew.

*Agriotes lineatus*, L.—If lime is not directly injurious to the larvæ of this insect spread on the fields, it helps greatly to diminish their numbers. According to Schilling, annual liming yields still more complete results. This improvement is due to the transformation effected by the lime on the soil, which after having been wet and charged with humus favourable to the evolution of the larvæ becomes drier after liming and unfit for their development.

*Gryllotalpa vulgaris* (mole cricket).—In Italy this orthoptera is removed by liming at the rate of 16 cwt. to the acre.

The larvæ of some Hymenoptera are very sensitive to lime.

*Ptereneus ventricosus*, Kl., *N. ribis*, Scop. (the gooseberry and currant saw-fly).—Lime in itself forms a good means of destroying their larvæ. Firor, however, prefers a mixture of 4·4 lb. of lime and 2·2 lb. of powdered tobacco which he spreads on the shrub after moistening it.

*Selandria* (*Eriocampa*) *adumbrata*, Kl. (slimy caterpillar, slimy larvæ of pear saw-fly).—Lime forms an excellent means of destroying this sticky larva which skeletonizes the leaves of the pear.

Amongst the Lepidoptera a few may also be combated by lime. The large white garden butterflies are destroyed by dusting freshly slaked lime on plants and then watering them (Vial).

*Cheimatobia brumata*, L. (the winter moth, Evesham moth), *Sesia*

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Scolytus (Rugose). *Eccoptogaster regulosus.*—It preferably attacks small branches and limbs. The perforated parts of the tree turn yellow and die. Plum-trees are especially chosen by it.

[1] Bostrichus (Borers).—Small Coleoptera belonging to the family of the Scolytides, distinguished by their cylindrical and bomb-shaped body, by their thick head drawn back into the thorax.

[2] Colaspidema ater.—Black lustrous, 3 millimetres long. The colaspidema is a plague of the lucerne fields of the south of France.

*myopiformis*, Bkl. (sesia of the pear), *Grapholitha Wœberiana*,[1] W. V.—The liming of the trunks prevents the females of these butterflies from depositing their eggs. The caterpillars of the last two butterflies may be destroyed by plastering the trees with a thick milk of lime mixed with clay (Taschenberg) and applied at the time the caterpillar is making its ravages.

*Tingis piri.*—This *Hemiptera* has been successfully combated by lime, which ought to be applied as a whitewash in February. The *Homoptera* have likewise been fought by lime with more or less success, for here again it is still by its desiccating properties that it especially acts. By using milk of lime as thick and hot as possible the contraction of the lime detaches the coccides and kills them at the same time. But a good result is not obtained unless care is taken to prune the tree and clean it from top to bottom. Thus cleansed and covered with a layer of lime the tree is not attacked by coccides, and the fumagine (fruit tree smut) which only lives on the dejections of these insects is avoided. Liming is thus an indispensable operation in arboriculture and it gives good results if renewed each year.

*Coccus vitis*, L. (red coccis of the vine, vine scab).—Winter is the best time to attack coccids, for that is the time that these insects get on to the trunks to lay their eggs. Bellot des Minières advises after pruning to clean the trunk completely, including scraping and careful barking. It is then whitewashed with lime, which protects it against these insects.

*Aspidiotus perniciosus*, Comstock (San José louse).—To combat this coccis the Americans replace lime by a mixture of salt, sulphur, and lime, sold as " salt lime and sulphur wash." Applied in winter on the trunks of trees this mixture forms a hard crust which prevents the reproduction of this insect (see below, p. 158).

*Schizoneura lanigera*, Hausmann (woolly aphis).—Muller advises coating the ulcerated spots infested by this aphis with milk of lime after having completely cleaned them. To destroy the woolly aphis, which live underground around the stock and the roots, Goethe advises to strip the trees in autumn or winter to a depth of 2 feet, and water them copiously with milk of lime. A layer is then made 3 centimetres, say 1·2 inches, thick of quicklime, then the earth is covered in. Taschenberg finds this method very efficacious. To combat *green lice*, Arbrinjer advises liming the whole tree in winter or spring. If an insecticide be added to the lime, such as tar or naphthalene, success is complete, for in that case the eggs of the louse are killed at the same time as those of the most diverse insects. Balbiani's mixture, as well as milk of lime, is incapable of preventing the opening of the buds, which are thus protected against insect attacks.

*Limaces* (snails) are also killed by lime. If it is a case of destroying snails on plants, freshly slaked lime is blown on to them from a bellows. Each snail touched dies forthwith. The best time for this operation is early in the morning, or in the evening a little after fall of day. In vineyards, the buds are protected against small snails by spreading slaked lime in powder on the stock, and laying a train of lime, 7—8 inches, around each stock. In the fields, lime is shown by hand at the rate of 25—30 bushels of slaked lime per acre. In destroying snails lime spread as an impalpable powder gives the best results. The operation is repeated several times if it is desired to reach all the snails. Lime used against snails tends to be replaced by nitrate of soda, tobacco powder, but especially by a 3—4 per cent. solution of blue vitriol. This solution is sprayed on the plants at the time the snails are on their rounds; the snails which are attacked die immediately and those which pass on to a branch covered with blue vitriol are likewise poisoned.

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[1] GRAPHOLITHA WŒBERIANA (tinea of stone-fruit trees); TORTRIX (*Carpocapsa*) WŒBERIANA.—The caterpillar of this microlepidoptera perforates the bark of plum-trees, peach-trees, apricot-trees, and almond-trees, penetrates into the alburnum and there undergoes metamorphosis. It kills the bark by the wounds it produces; it causes canker and a flow of gum. It prefers the peach and the plum.

**Use against Mammals.**—According to Taschenberg, plants are preserved from rabbits, hares, deer, by coating with lime. It is preferable to add strong smelling substances, such as petroleum, aloes, lard (rubbing a skin of lard against the trunks of 100 trees suffices). To impart more adherence and thickness to this paste, it is well to add cow dung and thin it down with purin. Seed can be protected against mice by coating them with a thick milk of lime and spreading petroleum thereon. They are then sown immmediately after this treatment. Such seed are not attacked by rodents.

**Late Frosts.**—Lime is successfully used against late frosts. When frost is to be feared, slaked lime in powder is spread on the buds of vines and fruit trees from a bellows so as to cover all their surface. These buds well covered with lime will not be attacked by the frost nor burnt by the sun striking them afterwards. With fruit trees it is necessary to operate before the blossoming of the flowers, or after fructification has taken place.

**Calcium Monosulphide.**—**Preparation.**—(1) By heating lime in a current of sulphuretted hydrogen; (2) by heating a mixture of sulphate of lime and charcoal; (3) by boiling milk of lime with sulphur; the polysulphides are so prepared, but by using larger proportions of sulphur. The product obtained by boiling milk of lime with excess of sulphur is called *calcareous liver of sulphur*. The paste bouillies employed to combat plant diseases are of very diverse compositions, and contain either a basic monosulphide or a monosulphide or polysulphides of calcium. They are generally prepared by boiling a milk of lime with flowers of sulphur, until the latter is completely dissolved. After cooling there are incorporated as occasion requires very diverse substances, such as glycerine, soft soap, copper salts, naphthalene, etc. To prepare and preserve these pastes, enamelled vessels are used. The bouillie recommended by Mohr is the one most in use. It is made thus: 22 lb. of quicklime are slaked, then made into a milk of lime and run through a sieve; on the other hand, 11 lb. of flowers of sulphur are stirred into 2·2 gallons of crude glycerine; the two liquors are mixed and the bulk made up to 22 gallons of liquid which is boiled for one hour over a small fire. A concentrated solution is thus obtained marking 18—20° Bé., which is appropriately diluted when required for use, to suit it for particular purposes, with 10—12 parts of water. It is best to dilute it with a milk of lime of 0·5 per cent. strength. Crouzel's anticryptogamic is prepared thus: 14 oz. of lime are slaked and the milk of lime therefrom run through a sieve, 35 oz. of sulphur added and the whole completed with water so as to produce 150 oz. of bouillie. When a homogeneous mixture is obtained, it is brought to the boil for an hour, care being taken to replace the water evaporated. The solution is filtered or decanted; it marks 20° Bé., 0·1 oz. of naphthalene is added and 2 oz. of hyposulphite of soda, and the whole completed with water to 100 gallons. This preparation is used as it is against the cryptogamic diseases of the vine.

Numerous methods of preparing lime-sulphur wash, as followed by practical orchardists, have been investigated by the U.S. Bureau of Entomology, or tested by it in the course of its experimental work. The following formula and method of preparation have uniformly resulted in a satisfactory wash, and are quite simple :—

| | |
|---|---|
| Lime . . . . . . . . . | 20 lb. |
| Sulphur (flour or flowers) . . . . | 15 lb. |
| Water to make . . . . . . | 50 galls. |

*Preparation.*—Heat in a cooking barrel or vessel about one-third of the total quantity of water required. When the water is hot add all the lime, and at once add all the sulphur, which should previously have been made into a thick paste with water. After the lime has slaked, about another third of the water should be added, preferably hot, and the cooking should be continued for an hour, when the final dilution may be made, using either hot or cold water as is most convenient. The boiling due to the slaking of the lime thoroughly mixes the ingredients at the start, but subsequent stirring is necessary if the wash is cooked by direct heat in kettles. If cooked by steam no stirring will be necessary. After the wash has been prepared it must be well strained as it is being run into the spray pump barrel, or tank.

The ingredients of the wash, in proper proportion, are boiled together in water, by which means chemical action between the lime and sulphur is brought about, producing in solution the insecticidal properties of the wash, the extent of chemical action depending directly upon the length of time cooking continues. From 45 minutes to an hour of vigorous boiling will put practically all of the sulphur into solution, and preference should be given to the latter period. A properly cooked wash is a heavy, caustic, orange-yellow liquid, with a strong sulphurous odour. Upon standing, the sediment settles to the bottom, leaving the liquid relatively clear.

A highly concentrated lime-sulphur solution may be made by using the lime and sulphur at the ratio of 1 to 2 as is usually recommended, but with reduced quantities of water. The formula used in the commercial lime-sulphur manufacturing plants visited and also in the foregoing experiments is as follows :—

| | |
|---|---|
| Fresh stone-lime . . . . . . . | 80 lb. |
| Commercial ground sulphur . . . . | 160 lb. |
| Water to make the finished product . . . | 50 galls. |

While there is about 50 per cent. in volume of sludge after allowing this solution to settle for 24 hours, there is only about 5 to 10 per cent. in volume of insoluble materials. These consist of sulphites, free lime, free sulphur, magnesium compounds, etc., varying with the kind of lime used and other conditions. Solutions prepared by this formula should test on an average 33—34° Bé.

The caustic, disagreeable character of the wash is frequently complained of by orchard workers. Much may be done to remove the objections to its use by spray gangs by supplying the men with rubber coats and gloves. The use of vaseline on the face is advisable in working during windy weather, and clear glass goggles may be used to protect the eyes. Lime–sulphur wash is very hard on the pumps, and these should be thoroughly cleaned at the close of each day's use.

*Self-boiled Lime–Sulphur–Caustic–Soda Wash.*—The expense of establishing cooking plants and of their operation constitutes an important objection to the lime–sulphur wash, and some attention has been given by U.S. entomologists to the devising and testing of washes made simply by the heat generated by the slaking of the lime, or by the additional heat following the addition of caustic soda. To prepare this wash, place in a suitable barrel or other vessel 30 lb. of good quicklime and start slaking with sufficient hot water to prevent air-slaking. As soon as the slaking is well under way add 15 lb. of sulphur previously worked into a paste with water, and stir thoroughly. Hot water is added from time to time in sufficient quantity to bring the mixture up to a thin paste. After slaking has ceased add 5 or 6 lb. of commercial caustic soda, stirring until the soda is dissolved. To this should be added sufficient water to bring up to 50 gallons of wash.

**Properties.**—Calcium sulphides are soluble in water, and in all proportions. Moistened with water and in contact with air they are rapidly converted into carbonate of lime and sulphuretted hydrogen.

$$CaS_2 + CO_2 + H_2O = CaCO_3 + H_2S + S.$$

But simultaneously with this decomposition they undergo partial oxidation into hyposulphite of lime. Calcium sulphides are neutral. They act by the amount of sulphur which they contain. To prevent their too rapid decomposition in moist air, various substances have been incorporated, such as glycerine and milk of lime, in the proportions given by Mohr (p. 157), molasses, soft soap, in the proportion of 1—2 per cent. These substances also cause the bouillies to adhere better to plants.

**Action on Plants.**—Calcium sulphides are less injurious to the green parts of plants than potassium sulphides, because their solutions are not caustic. Solutions of glycerinated monosulphide may dry on the leaves without injuring them. But in spite of that it is necessary to avoid the too rapid decomposition of these sulphides for the sulphuretted hydrogen produced is very injurious to the plant; 0·75 per cent. of this gas diffused through the air may poison certain plants. The use of glycerine to form bouillies, and of water and lime to dilute them prior to use, helps greatly to attenuate the effect of this gas; by delaying the decomposition of the sulphides, too large an amount of sulphuretted hydrogen is prevented from being formed at one time. The damage caused to different plants, as well as on the roots treated, is likewise caused by hyposulphite of lime often present in impure calcium sulphides; hyposulphites scorch the leaves especially during strong summer heat. Owing to their reducing action sulphides, and particularly calcium sulphides, are injurious to the roots which come in direct contact with it.

**Action on Fungi.**—The action of calcium sulphide on the mycelium of fungi is in principle the same as that of sulphur, but polysulphides, which are in a way solutions of sulphur, may be looked upon as more active than sulphur, even used in its most impalpable form. Whilst sulphur has no radical action on the *Erysipheæ*, the mycelium of which is exposed without any protection on the surface of plants, calcium sulphides act on fungi which live in the plant itself.

**Action on Insects.**—Generally insects are not disturbed by solutions of calcium sulphide. It is otherwise with acari, plant lice, which are easily destroyed by this preparation. Sulphides are, so to speak, specifics against the *Phytoptides* which produce the different *erinoses* of plants and the most diverse galls. Used against these pests their action, otherwise very imperfect, is solely due to the sulphuretted hydrogen given off, which is exceedingly poisonous to these insects.

**Use against Fungi.**—Calcium sulphides form an efficacious and econonic means for the destruction of the most various parasites. They are practical substitutes for sulphur. They have in themselves a remarkable action; but it is well to incorporate in their solutions substances capable of protecting them against moist air which renders them inactive too soon and causes them to poison plants. Mohr advises their use against cryptogamic diseases.

The British Ministry of Agriculture recommends, against apple mildew (*Podosphæra leucotricha*) and apple and pear-tree scab, also American gooseberry mildew, that lime–sulphur solution sold for agricultural and horticultural purposes should be made from lime, sulphur, and water only. The specific gravity of the solution as sold should not be less than 1·3 at 15° C.

The summer stages of the European red mite (*Tetranychus telarius*) are controlled in Maryland on apple trees by the regular spray schedule of lime–sulphur 1 : 40, if the spraying is thoroughly done. If the foliage of apple becomes infested during the summer, a lime–sulphur spray diluted to 1 part in 75 parts water is used, with a spreader such as calcium caseinate or flour.

*Anarsia lineatella* (peach twig moth), a serious pest, particularly of the late variety of peaches, may be kept under control by delayed dormant spraying with lime–sulphur. A dormant lime–sulphur spray applied when the buds are swelling or even opening is recommended against *Eriophyes pyri* (pear-leaf blister mite); a second spray, consisting of one-third the winter strength, should be applied in the cluster bud stage, and just before the blossoms open.

In Nova Scotian apple orchards, against scab and scabby blotch, codlin moth, brown tail moth and aphis most growers spray three or four times, and the best of them five or six times. The first spray consists of lime–sulphur of 1·009 specific gravity or 3 gallons commercial strength to 100 gallons of water (1 to 33), with the addition of arsenate of lime 2 lb. to 100 gallons. This is put on at 200 lb. pressure when the trees are in the green bud stage. For the second spraying, just before the blossom buds have opened, weaker lime–sulphur (1 to 43) and arsenate of lime is used. The third spray, after the petals have fallen, consists of lime–sulphur 1 to 50 and arsenate of lime 1½ lb. to 100 gallons. Two weeks later the fourth spray is used and this consists of Bordeaux mixture (7 lb. copper sulphate, 7 lb. quicklime to 100 gallons) with 5 lb. paste lead arsenate added to each 100 gallons. In very wet seasons a fifth spray, similar in material to the fourth, is used two weeks later to control apple scab.

*Cuscuta* (dodder).—Carrigon employs calcium sulphide with success to destroy the vegetable parasite dodder in forty-eight hours. To obtain this effect calcium sulphide is spread on the ravaged parts of the field, and these spots sprayed slightly with water. The result is especially favourable in wet weather. If this treatment is applied before the maturity of the grain the dodder may be considered as eliminated from the fields.

*Peronospora viticola*, de By. (mildew of the vine).—Vesque recommends polysulphides against this parasite of the vine. A bouillie is prepared for the purpose with 1 lb. of quicklime to 3 lb. of sulphur in 10 gallons of water. The leaves and the grapes are sprayed at the time the vine is usually sulphured.

*Erysipheæ* (mildews).—All these fungi can be destroyed by calcium sulphides; they act on their mycelium disorganizing them rapidly like sulphur. Their use is, however, more simple, their action more regular, because it does not depend on the temperature which, as regards sulphur, is one of the conditions of success. Besides, solutions being spread more uniformly on the organs of the plant attacked the action is more thorough.

*Uncinula americana*, How. (oidium of the vine).—Crouzel recommends his "anticryptogamic" against the oidium, the composition of which has already been given. Spraying ought to alternate at five or six days' interval with cupric preparations. Polysulphides employed without naphthalene or hyposulphite produce the same effect, and Mohr's preparation arrests the oidium in full evolution. In the spring 4 per cent. solutions of polysulphides are used, 5 per cent. solutions after flowering, and 6 per cent. solutions at the end of summer. The latter do not injure the leaves. In the same way as for the oidium, mildew of the vine, the polysulphides of calcium have been used to destroy the following *Erysipheæ* (mildews): *Sphærotheca pannosa* (mildew of the rose and the peach); *Microsphæra grossulariæ*, Wall. (mildew of the gooseberry); *Erysiphe communis*, Wall. (mildew of hay and clover). Nijpels recommends to use against mildew of the rose a sulphide prepared thus: boil 100 gallons milk of lime made with 20 lb. of quicklime and 40 lb. of sulphur; after twenty minutes' boiling the sulphur is dissolved and the whole cooled. A teaspoonful of this solution per litre of water for spraying suffices, which should be done two or three times during summer.

*Capnodium* (fumagine).—The fumagine (fruit tree smut) is destroyed by 5 per cent. sulphide solutions, but according to Franck and Kruger this product cannot destroy the coccides which produce it.

Amongst the black-blights there are also some which may be combated with polysulphides: *Gloeosporium ampelophagum*, Sacc. (anthracnose of the vine). Against this disease it is necessary to apply a spraying of sulphide before the flowering of the vine.

*Cladosporium fulvum*, Cooke (tomato disease).—Mohr particularly advises the use of polysulphides against this disease which act in a more efficient manner than copper salts.

*Actinonema roseæ*, Fr. syn. (*Asteroma radiosium*, Fr.).—Mohr recommends two or three sprayings during summer.

*Hypomyces perniciosus*, Magnus (mole disease).—Constantin and Dufour found that this disease can be combated by calcium sulphides.

*Nectria ditissima*,[1] Tul. (canker of the pear-tree, canker of the apple-tree, canker of the beech-tree); *Nectria cinnibarina*,[2] Rode. (necrosis of wood).—Mohr advises to combat these two parasites with glycerinated sulphides. The wound is deeply incised, cleaned, and then coated several times with a solution of glycerinated sulphide of calcium, titrating 15—25° Bé. When the wound is dried up it is covered with a linseed oil varnish (? boiled oil). To obtain a cure it is sometimes well to repeat this treatment several times a year. It is also recommended to use a concentrated solution of sulphide mixed with a thick milk of lime and to coat the wound after drying with a mastic of some sort.

*Fusicladium pirinum*, Fuckel (pear scab); *Fusicladium dentriticum* (apple scab).—Mohr advises the use of glycerinated sulphide of lime, of the usual strength, as soon as the fruits have formed and are the size of a pea, two or three additional sprayings being given during the summer.

*Hydnes* and *Polypores* are combated with calcium sulphides: *Hydnum Schiedermayri*,[3] Heufl.; *Polyporus sulphureus*,[4] Fries; *Polyporus igniarius*,[4] Fries (false tinder fungus).—Mohr advises to combat this disease by excising all the diseased wood and to plaster the wounds several times with glycerinated sulphide of lime of 20° Bé., then to coat with mastic. Mohr also advises to combat certain rusts with calcium sulphide thus: *Phragmidium subcorticum*, Schrank (rose rust), and also the rust of the pines and spruces, such as *Chrysomyxa abies*,[1] Unger (rust of needles of Epicea), and others. The treatment should be carried out in May so as to avoid fresh infection of the plant. *Peridermium pini*,[2] Walr. (vesicular rust of the bark of the pine); *Peridermium oblongisporium*,[2] Fuckel (vesicular rust of pine needles). -Mohr advises to combat these diseases with his bouille diluted with 10—12 parts of water. The result it appears is as good as with Bordeaux bouillie.

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[1] Nectria ditissima (canker of the apple-tree, the pear-tree, and the beech).—This fungus is the immediate cause of some cankers which gnaw the branches of the apple-tree and the pear-tree. It is one of the most formidable diseases of fruit trees.

[2] Nectria cinnabarina (necrosis of wood; coral spot disease).—This fungus, which generally lives as a saprophyte on dead wood, appears also as a parasite and corrodes the wood. It attacks the horse chestnut, the maple, the ailantus. Its mycelium not only extends into the bark but into the wood itself; it is a parasite of the ligneous body like the *Polyporæ*, which live at the expense of the starch.

[3] Hydnum Schiedermayri.—This fungus is an apple-tree parasite which rots the wood. It bores the trunk, forming great holes of rot, whence issue in autumn irregularly shaped, yellow, fleshy receptacles, which may reach 5 centimetres (2 inches) in diameter and 10 centimetres (4 inches) thick. They smell of anise.

[4] Polypora.—These receptacle fungi form projecting lamellæ either fleshy or ligneous in the form of a bracket or a horse-shoe attached laterally by their base in the interior of which their mycelium is spread. Polypores attack fruit trees. They cause white rot especially of the wood of the oak. Polyporus igniarius (false tinder fungus).—As widespread as *P. sulphureus*, it preferably attacks very old oaks and there causes white rot, but it also shows itself on the beech, the poplar, the hornbeam, the willow, and on fruit trees. Polyporus sulphureus (heart wood rot).—This widespread fungus especially attacks the oak, the walnut, the pear-tree, and the poplar. Where it fructifies yellow sulphurous hoods appear rising one above another.

*Exoascus deformans*,[3] Fuckel (Cloque du Pecher), (blistering, wrinkling, or curling up of the leaves of the peach).—Pierce and Mohr advise spraying with calcium sulphide to prevent this disease; according to these authorities complete success is obtained if, as soon as it makes its appearance on the first leaves, they are sprayed with a 4 per cent. solution.

**Use against Insects.**—*Carpocapsa pomonella*, L. (codlin moth, apple worm, pyralis of the apple).—Mohr advises calcium sulphide glycerinated to $\frac{1}{10}$ to prevent apples becoming wormy. To prevent the hatching of the eggs laid by the female on the young fruit a first spraying should be made as soon as the fruit is formed or soon after flowering; the fruit should be inspected from time to time and sprayed afresh where required.

*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—Mouillefert tried to determine the action of calcium pentasulphide on this pest by making injections round an infested stock, amounting in all to 350 cubic centimetres, of a solution of 23° Bé. diluted with 7 litres of water [twenty times its volume]. The result was perfect on the upper roots but not complete on the deep roots.

*Aphides* (naked plant lice).—Many observers have recommended 2—4 per cent. solutions of calcium monosulphide and even the same product in the form of powder as a specific against green lice.

*Aphis persicæ*, Sulz, which is destroyed at the same time as the leaf curl (Exoascus deformans) by a 4 per cent. solution; likewise the *Aphis oxyacantha*, Koch, which causes the cloque of the hawthorn; *Aspidiotus perniciosus*, Comstock (San José louse); *Aspidiotus aurantii*, Maskell (coccis of the orange). The Canadian Government advises for the destruction of these dangerous coccides a bouillie consisting of 18 lb. of slaked lime, 18 lb. of sulphur, and 5¼ oz. of blue vitriol in 10 gallons of water. For the same purpose there is used in California a bouillie composed of 6 lb. of slaked lime, 3 lb. of sulphur, and 2 lb. of common salt (the latter added at the moment it is to be used) in 10 gallons of water. This bouillie, it appears, also kills the woolly aphis. According to the researches of Coquillet these two bouillies even used of double strength are not capable of entirely freeing the trees from their parasites. They only destroy 50 per cent. Mohr likewise found these bouillies incapable of replacing more active ones, and Franck and Kruger regard this means as insufficient to combat the different species of coccides. Garrigou found that calcium sulphide spread in fine powder on the young moving lice followed by spraying with water very effectual. Calcium sulphide in powder is a specific for the destruction of acari, against which it yields perfect results.

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[1] Rust of Spruce Needles. *Chrysomyxa abies.*—The young needles attacked in the course of summer turn yellow where the fungus is localized.

[2] Rust (Vesicular) of the Bark of the Pine. *Peridermium pini, Pine Cluster Cups.*—In May bladders or whitish membranous sacs, which split to let the æcidium spores which they contain, and which form an orange dust, escape, are seen to appear on the pines, chiefly at the foot of the stem of the young plants, or on the branches of adult plants. The mycelium extends between the bark and the liber, and sinks into the wood through the medullary rays. Rust (Vesicular) of Pine Needles. *Peridermium oblongisporium.*—This rust is similar to the preceding, but it is localized in the needles.

[3] Exoascus deformans (leaf curl of the peach).—This disease is caused by the complete deformation of the leaves, which thicken, curl, twist, and swell, assuming a pale yellow to rose tint. When the disease reaches a certain pitch, the young branches are also invaded and deformed.

Calcium sulphide may prevent the premature fall of the leaves produced by the saw-fly; it also prevents the *erinoses* produced by the *Taphrina*, Fr., *Erineum*, Pers., and *Phyllerium*, Fr.; it also destroys the *Phytoptides* which produce galls. As a preventive against these diseases spraying round the plant and on the branches must be advised in winter after the fall of the leaf and in spring before the opening of the buds. Coating the tree with a strong bouillie so as to cover all the buds occupied by these parasites is still more efficacious. The U.S. Minister of Agriculture advises to destroy *Eriophyes ribis*, Nal., syn. *Phytoptus ribis*, Wester (currant gall mite), and *Eriophyes vitis*, Land., syn. *Phytoptus vitis*, Land. (erinosis of the vine), the use of a bouillie consisting of 6 lb. of lime and 6 lb. of sulphur in 100 gallons of water. To increase the effect of the calcium sulphide 12½—25 lb. of soft soap may be added. The milk of lime is boiled with the sulphur and the soft soap dissolved in water added. Miss Ormerod (the late) and also Debray greatly recommend calcium bisulphide and found it superior to sulphur. Taschenberg finds that a little alum renders its solutions more active.

**Calcium Chloride,** $CaCl_2$.—**Preparation.**—By treating marble with hydrochloric acid. The crystals of $CaCl_2,6H_2O$ thus obtained are heated to igneous fusion; the mass is then cooled on a smooth surface on which the chloride solidifies in white flakes with a crystalline fracture.

**Properties.**—Fused calcium chloride has great affinity for water (*i.e.* is highly deliquescent); in contact therewith it dissolves with evolution of heat.

**Use.**—Comstock and Slingerland tried this product, comparatively against other substances, to fight the larvæ of *Agriotes lineatus* (wire-worm), but did not obtain good results. Neither was Waite able to destroy lichens by the use of a 1 per cent. solution, whilst Jack recommends it in strong doses to kill *Equisetum palustre*, or poisonous horse-tail, in meadows.

**Chloride of Lime (Bleaching Powder),** $CaCl_2O$.—**Preparation.**—Commercial bleaching powder is a mixture of hypochlorite of lime, calcium chloride, and lime. It is prepared by spreading slaked lime in thin layers on trays laid in a masonry chamber, and passing a current of chlorine over this moist lime, so that a certain amount of unchanged lime remains at the end of the operation, which enables the chloride of lime to keep longer, by protecting it against the carbonic acid in the air.

**Properties.**—Chloride of lime is a white powder with an acrid taste, exhaling an odour of hypochlorous acid, $HClO$; it dissolves freely in water, leaving a white residue of hydrate of lime. The weakest acids, such as carbonic acid, decompose chloride of lime with disengagement of hypochlorous acid; chloride of lime must therefore be preserved out of contact with air. The hypochlorous acid which is given off has a very energetic action on organic matter, towards which it acts as an oxidizing agent. This action is more rapid in presence of a mineral acid.

**Use.**—Kolbe recommends chloride of lime to destroy poisonous horse-tail (*Equisetum palustre*). In doses of 352 lb. per acre its destruction is complete. Chloride of lime has been used to destroy insects. It has been tried against—

*Spilographa cerasi*, F., syn. *Trypeta cerasi* (cherry fly).—Taschenberg recommends to prevent cherries from becoming wormy to spread, after the fall of the cherries, around the tree a hot 1 per cent. solution of chloride of lime, which destroys the larvæ buried in the ground.

*Formica* (ants).—Taschenberg proposes for the destruction of ants to spread on their nests a mixture of chloride of lime and of purin, or to mix the earth of the nest with chloride of lime and to water immediately afterwards with dilute hydrochloric acid. Cuboni believes that in spraying fields with a milk of chloride of lime they are freed from almost all parasites, and mice and moles are driven away. The odour of this product would appear to be unpleasant to insects, and the presence of chloride of lime suffices to prevent them from laying their eggs. This property has been utilized in arboriculture. For this purpose a mastic is prepared, with 1 part of fat and 2 parts of chloride of lime in powder, and a ring of this preparation applied round the trunk. According to Muhlberg, it suffices to suspend on the tree a small basket filled with chloride of lime. Needless to say the chloride of lime must be renewed as soon as it ceases to emit any more hypochlorous acid.

**Sulphate of Lime,** $CaSO_4$.—**Preparation.**—Gypsum, or plaster stone, is a natural, crystallized sulphate of lime, $CaSO_4,2H_2O$. It is found in large quantities in the Trias and Permian. These deposits are the result of the evaporation of ancient selenitic waters. Crystallized sulphate of lime is rapidly and almost completely dehydrated at about 120° C., being converted into plaster of Paris, which contains no water but which retains the property of easily taking up its water of crystallization once more when again moistened. This precious property is lost if the gypsum is heated to 160° C. To obtain sulphate of lime commercially the plaster stone is piled up at the quarry mouth in rude arches under a shell made from combustible material, or in special furnaces. The blocks must leave between each other interstices of sufficient size to allow the flame of wooden faggots lit in the lower part to pass. A very moderate fire is kept up, which penetrates the mass slowly and dehydrates it. The plaster so obtained is pulverized in mills and preserved out of contact with moisture.

**Properties.**—Sulphate of lime is slightly soluble in water; 1 litre of water at 0° C. dissolves 1·9 grammes; at 38° C. 2·14 grammes; at 99° C. 1·75 grammes; it is much more soluble in hydrochloric acid.

**Action of Sulphate of Lime.**—Its action is due to its hygroscopic power and its fine division, which asphyxiates the insects by penetrating into the respiratory passages.

**Use of Plaster [1] against Fungi.**—Sorauer advises abundant manuring with plaster to prevent the rotting of roots due to the development of the most diverse fungi, such as *Armillaria mellea*, Quellet, *Fibrillaria xylothrica*, Linh., *Rhizoctinia violacea*, Tul.; this manuring has sometimes given good results.

*Botrytis cinerea*,[2] Pers. (grey rot of the vine).—Sorauer advises the use of plaster in the same condition as slaked lime in fine powder. As soon as this dreaded disease appears, plaster is sprayed on the fruits; the fruits are thus protected, for the fine layer of plaster which covers them prevents the fungi from finding on the surface of the grape a propitious soil for their development. Recommended for the first time by De la Bathie, experiments made in the South of France have not given the good results described.

**Use against Insects.**—Plaster, having no caustic action, can only act as an asphyxiant. Owing to its extreme fineness, it is introduced through the stagmata into the respiratory organs of insects, where under the influence of moisture it hydrates, swells, and causes death. Without being mortal to certain larvæ, it annoys them very much and keeps them away from plants. Plaster is used with much greater success against *altises*. *Haltica ampelophagus*, Guer. (altise of the vine).—So that the effect may be perfect, it is necessary to powder the vine so that the plaster is projected on to the lower part of the leaves, for it is there that the larvæ and insects are. Brocchi greatly advises its use. But it is not the altise of the vine alone which may be combated in this way, the most diverse altises succumb or are driven away owing to its use.

*Haltica nebulosa*, L. (*Cassida nebulosa* [3]).—Doering advises the use of plaster against this larvæ as well as for the caterpillar of *Noctua gamma*.

*Plusia gamma*,[4] L. (silver Y moth).—The caterpillars of this *Noctua* abandon plants treated by plaster.

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[1] The author does not differentiate between gypsum and plaster but uses the term *plâtre* throughout. To follow him it will be well to bear in mind that in all probability when he refers to plaster as a manure he means gypsum, and when he refers to plaster as an insecticide he means plaster of Paris. It is a pity that writers on agricultural chemistry too often lose sight of the fact that superphosphate contains naturally about 50 per cent. of sulphate of lime in addition to what is added as a "reducer."—Tr.

[2] The conidia of *Sclerotina Fuckeliana*, de Bary.—Tr.

[3] Cassida nebulosa.—Coleoptera (chrysomelide) 1 centimetre long, oval, with lateral expansions of the corselet and elytra forming a carapace recalling that of the tortoise. The perfect insects hibernate and issue from their retreats in the spring. The females lay their eggs on the upper surface of the leaves of the beet. The larvæ, of a pale green colour with two longitudinal white stripes, attain 1 centimetre in length.

[4] Plusia gamma, Noctua gamma.—Greyish-brown moth of 4 centimetres with a silver spot which represents the Greek letter Gamma on each of its upper wings. The green caterpillars attack leaves of the cabbage, beet, potato, colza, hemp, flax, maize, peas, beans; there may be two or three generations a year.

*Melolontha vulgaris* (cockchafer).—Poli recommends to kill this larva to plough in 8 cwt. of plaster per acre along with the cruciferous plants grown for this purpose as intercalated crops. Plaster does not, however, act fatally, as does the sulphuretted hydrogen evolved by the fermentation in presence of organic matter.

*Hypera variabilis* (beet weevil).—Plaster renders the same service as lime in destroying the larvæ of this insect in lucerne fields. It suffices to throw a certain amount with the shovel on the infested plants. The larvæ of the saw-fly succumb by powdering them with plaster as well as with lime (Taschenberg).

*Snails and Slugs.*—Plaster used like lime destroys these mollusca.

*Rodents.*—Rodents are often destroyed by plaster. It is spread on a saucer and covered with a layer of flour, a second saucer is filled with water. The rodents begin to eat the flour, of which they are very fond, then the plaster. When they go to slake their thirst the plaster swells and agglomerates in their stomachs, causing death.

**Sulphite of Lime,** $CaSO_3,2H_2O$.—**Preparation.**—By treating milk of lime or chalk beaten up with water by sulphurous acid.

**Properties.**—Sulphite of lime only dissolves in 800 times its weight of water, but it is very soluble in sulphurous acid with which it forms calcium bisulphite.

**Use.**—J. de Sokolnicki used with success against the *Botrytis cinerea*, Pers. (grey rot of the vine) a powder of the following composition: alumed plaster 20 lb., bisulphite of lime 10 lb., Portland cement 15 lb., hydraulic lime 20 lb., green vitriol 35 lb. This powder used on vines from 8 May and during flowering kept the grapes free from rot. It is, moreover, known that bisulphite of lime destroys moulds because it is regarded as the best disinfectant for cellars infested with mould. It is also used to destroy the cryptogams which infest dairies, and for the preservation of beer. It is to be remarked that the mixture used against the black rot does not act solely through the bisulphite of lime, but rather by the alum.

**Calcium Carbide,** $CaC_2$.—**Preparation.**—By acting on an intimate mixture of quicklime and coke, with the high temperature of the electric furnace.

**Properties.**—It forms hard, compact scoriaceous masses without smell in dry air. In moist air it gives off an alliaceous odour. In contact with water it disintegrates and decomposes into hydrate of lime and acetylene.

A Bordeaux bouillie with calcium carbide substituted for the lime has been found effective in East Africa against coffee leaf disease (*Hemilia vastatrix*).

**Use.**—See also acetylene.

**Arsenite of Lime,** $CaAsO_3H$.—**Preparation.**—The paste of arsenite of lime used to destroy injurious insects is made by dissolving 1 lb. of white arsenic in 2 gallons of water, and running into the solution a milk of lime containing 2 lb. of lime. The mixture is heated for half an hour then thinned to make 100 gallons of bouillie. The arsenite of lime formerly used was the residue from the manufacture of magenta; it consisted largely of arsenite and arsenate of lime, and was sold under the name of London purple. As it was partially soluble in water it was necessary to add to it to render it harmless to plants an equal amount of quicklime under the form of milk of lime. In America they have even used a paste consisting of 60—120 grammes of London purple and 1·5—2·5 kilogrammes of lime in 100 litres of water.[1]

**Properties.**—Arsenite of lime is insoluble in water. The precipitate is light and keeps in suspension much better than the arsenite of copper. It has the advantage of being cheaper than Scheele's green and emerald green (Paris green); this is especially so as regards London purple, but the latter is variable in composition and its action on insects is comparatively weaker. Arsenite of lime, owing to its insolubility in water, is much more harmless to plants than arsenite of copper. Whitehead found the following doses harmless :—

45 grammes of purple in 100 litres for apple trees.[1]
50 ,, ,, pear and cherry trees.[1]
60 ,, ,, the plum, hazel, and cherry trees.[1]

The bouillie made with an excess of milk of lime is, so to speak, harmless to plants.

**Use.**—Arsenite of lime is used wherever arsenite of copper is capable of destroying injurious insects. Arsenite of lime has the advantage over arsenite of copper that it may be associated with *eau celeste* (see Chap. XV.) without dissolving therein. The bouillie thus obtained is one of the most efficient in simultaneously combating the following injurious insects and fungi :—

*Fusicladium dentriticum*, Fuckel (apple scab); *Carpocapsa pomonella* (pyralis of the apple, codlin moth).—The efficient bouillie contains London purple or arsenite of lime 0·050 per cent., copper carbonate 0·45 per cent., ammonia 0·5 per cent. After six sprayings made on 25 March, 1, 15, and 20 May, 26 June, and 14 July, Halstedt obtained 47·6 per cent. of sound apples and 3·46 per cent. of wormy apples, against 30 per cent. of sound apples and 6·7 per cent. of wormy apples. The same result was got by a mixture of Bordeaux bouillie and London purple. Carrol by three sprayings on apple-trees, the first soon after flowering, the two others at three weeks' interval, obtained apples quite free from worms, whilst the check samples contained 60 per cent. The first spraying and the second were done with a bouillie containing 0·06 per cent. of London purple and 1—2 per cent. of lime, the third with a bouillie containing 0·1 per cent. of purple and 2 per cent. lime.

**Calcium Arsenate,** $Ca_3(AsO_4)_2$.—Owing to its extensive use several new methods for the manufacture of calcium arsenate have been devised in the U.S.A. One of these utilizes a deposit of ferric arsenate, occurring near Salt Lake, Utah, as the source of arsenic. The method consists briefly in decomposing the iron arsenate with caustic soda solution, filtering from the ferric hydroxide, treating the filtrate with lime, and removing the precipitated calcium arsenate by filtration. The filtrate containing the liberated caustic soda is concentrated and used again. A process by which calcium arsenate is produced in one step has also been patented. It consists in mixing pulverized quicklime with a concentrated solution of arsenic acid in such proportions that the heat generated is sufficient to drive off what little water is present, producing a dry product which requires no further heating. Entomologists of the U.S. Department of Agriculture have found that calcium arsenate gives very promising results against the codlin moth, the fall webworm, the tent caterpillar, and the tussock moth. In the tests the effects of arsenate of calcium, both alone and combined with lime–sulphur solution, were tested in comparison with arsenate of lead alone and in combination with lime–sulphur. The arsenate of calcium, as was the arsenate of lead, was used at the rate of 2 lb. to each 50 gallons of water. In all the experiments the arsenate of calcium gave very satisfactory results in killing the larvæ without burning the foliage. In a number of cases its killing action was somewhat slower than, but compared favourably with, the arsenate of lead. Since it can be produced more cheaply than the lead arsenate it would appear to have distinct value, although it has not been sufficiently tested to permit recommending it unreservedly for general use. Where arsenate of calcium was combined with lime sulphur it was, as a rule, even more effective as a poisoning agent than when used alone and did not lessen the value of the latter as a fungicide. When these compounds are combined, the amount of foliage consumed by the larvæ is less than where the arsenate of calcium is used alone. In tests in 1914 a commercial arsenate of calcium (paste), arsenic oxide 18·82 per cent., with lime–sulphur solution gave very excellent control of the codlin moth in comparison with arsenate of lead and with unsprayed plots. Where arsenate of calcium was used, 98·79 per cent. of the apples were sound; arsenate of lead showed 99·44 per cent. of sound apples; while in the unsprayed tests plots only 58·71 per cent. of the apples were free from damage. The following was found to be a convenient way of making home-made arsenate of calcium: Stone lime (90 per cent. CaO), 55 lb.; sodium arsenate, fused (dry powders) (65 per cent. $As_2O_5$), 100 lb.; water, 26 gallons. Place the stone lime in a wooden container and add a small amount of water, just enough to start slaking. When slaking is well under way pour in the sodium arsenate, which should first have been dissolved in hot water. Keep stirring until the lime has thoroughly slaked. Sufficient water should be added from time to time to prevent burning. The resulting arsenate of calcium should contain about 18 per cent. of arsenic oxide. In making this compound it will of course be necessary to know approximately the calcium oxide and arsenic oxide content of the materials employed and to vary the formula accordingly. The by-product is largely sodium hydroxide, which should be decanted if the insecticide is to be used on tender foliage.

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[1] *Note by Translator.*—Grammes per 100 litres = parts by weight per 100,000 parts by volume or lb. per 10,000 Imperial gallons.

*Epilachna corrupta*, Muls. (Mexican bean beetle).—American recommendations for the control of *Epilachna corrupta* include dusting with 1 part of calcium arsenate and 9 parts of lime, or 1 part of calcium arsenate, 1 part of fine dusting sulphur and 4 parts of hydrated lime.

The most important use in the U.S.A. for calcium arsenate is in controlling the boll weevil [*Anthonomus grandis*, Boh.]. With calcium arsenate dust the saving is regarded as an average of 300 lb. of seed cotton per acre. Or, according to another estimate, the average increase in yields of seed cotton resulting from the use of calcium arsenate dust on comparable plots was 236 lb. per acre. One of the most effective methods of distribution is by scattering from aeroplane. For the earliest weevils appearing, constant hand-picking is recommended in small fields, or a light dust application of calcium arsenate before the cotton squares form. As infested squares are easily seen, it is easier to gather and burn them than to search for the insect, but this must be done every week or ten days at least.

U.S. authorities recommend that calcium arsenate for dusting cotton should contain not less than 40 per cent. of arsenic oxide and not more than 0·75 per cent. of water-soluble arsenic oxide, and that it should occupy a volume of from 80 to 100 cubic inches a pound.

*Heliothis* (*Chloridea*) *obsoleta*, Hb., is the principal insect pest affecting early tomatoes in Virginia. Of dusts and sprays the best results were obtained with dusting. Spraying, however, is recommended where its use avoids the necessity of procuring a fresh outfit. The dust used contained 16 per cent. of monohydrated copper sulphate, 64 per cent. of finely screened hydrated lime, and 20 per cent. of calcium arsenate. For spraying in 1922 a Bordeaux mixture was used, composed of 4 lb. of copper sulphate, 6 lb. of quicklime, and sufficient water to make 50 U.S. gallons. Two pounds of powdered calcium arsenate were added to each 50 U.S. gallons. In 1923 a similar spray was used substituting 8 lb. of hydrated lime for the 6 lb. of quicklime. Treatment should be started in the seed-bed and continued at intervals of from seven to ten days in the field as soon as the plants are well established.

**Calcium Cyanide,** CaCN—Success in controlling ants with calcium cyanide was recently obtained in Sedgwick county, Kansas, according to the "Farm Bureau News," of America. Holes were bored into the ant mounds at well-defined entrance places of the ants, the holes varying in depth from 4 to 18 inches, depending upon the amount of tunnelling. From one to eight holes were bored in each mound, depending on the size. Calcium cyanide flakes were poured into each hole. It is necessary that the earth be moist when this is applied as the gas is given off only in the presence of moisture. An examination five days afterwards showed that the ants were killed in over 75 per cent. of the mounds. Calcium cyanide flakes, using 100 lb. to the acre, gave complete control of pea aphis (*Acyrthosiphon pisi*) in Kansas; the lucerne was badly scorched but soon recovered. Both 2·7 and 4 per cent. nicotine dust, at the rate of 50 and 30 lb. per acre respectively, gave fair results.

*Erythroneura* (*Typhlocyba*) *comes*, Say.—Calcium cyanide dust has been tried with promising results. The leaf-hoppers are overcome by the gas and fall to the ground, where they do not recover if some of the calcium cyanide is on the ground. To ensure this the plants were treated with a knapsack duster from below so that the heavier particles dropped to the ground.

*Wireworms.*—The application of calcium cyanide to soil in which potatoes, bulbs and young seedling trees are growing causes injury to the roots or tubers when the cyanide was placed close enough to the plants or used in sufficient quantities for effective killing of wireworms. The cyanide remains in the soil for only a short time, however, and it is safe to begin planting within a week or ten days after its application. The right depth appears to be about 4—6 in. Two hundred pounds per acre, if properly applied, will kill 75 per cent. or more of wireworms, and the benefit of one treatment will extend over two or three years at least.

*Calcium Cyanide as a Greenhouse Fumigant.*—Experiments were conducted by the U.S. Bureau of Entomology during 1924 for the purpose of determining how soon after exposing calcium cyanide to the atmosphere of a fumigation box the gas evolved would reach a satisfactory killing concentration, and whether an overnight exposure at a concentration as low as ¼ oz. of calcium cyanide per 1,000 cubic feet of air space would be effective. Three series of tests were made in a box of 200 cubic feet capacity, using calcium cyanide dust in one series, granular calcium cyanide in a second, and sodium cyanide, as a control, in the third, with exposures lasting from 1—7 hours inclusive, and a period of 15 hours, all night; on four species of Aphids, *Myzaphis* sp. on rose, *Aphis rumicis*, L., on nasturtium, and *Macrosiphum* (*Macrosiphoniella*) *sanborni*, Gill., and *Rhopalosiphum rufomaculata*, Wils., on chrysanthemum. The doses were at the rate of ½ oz. of calcium cyanide or ¼ oz. of sodium cyanide (the approximate equivalent) per 1,000 cubic feet. Overnight fumigation showed a mortality of 100 per cent. in each test. On rose, scorching began about the sixth hour, and on chrysanthemum occurred more or less throughout the series. Twenty-five large commercial greenhouses were then fumigated for 12—15 hours with a dosage of ¼ oz. granular calcium cyanide per 1,000 cubic feet, the plants in them being infested with Aphids, chiefly *Myzaphis* sp. The control was excellent and the scorching on roses negligible. Other tests gave similar results with *Myzus persicæ*, Sulz., on carnations, *Illinoia pisi*, Kalt., on sweet peas, and *Macrosiphum sanborni* on chrysanthemums. Large orchid houses were fumigated with a 1 oz. dosage, resulting in a 100 per cent. mortality of the scale, *Diaspis boisduvali*, Sign., and 52 per cent. of the chaff scale, *Parlatoria proteus*, Curtis, without injury to the plants. Satisfactory results were also obtained with the greenhouse whitefly, *Trialeurodes vaporariorum*, Westw., on various plants, at the ¼ oz. dosage. With calcium cyanide the gas is given off rather more slowly, and a longer exposure may be required than with sodium cyanide. Calcium cyanide is, however, easier to use, and for that reason may be more generally adopted by florists.

# CHAPTER IX

## MAGNESIUM CHLORIDE—MAGNESIUM SULPHATE (EPSOM SALTS)—MAGNESIUM BISULPHITE—MAGNESIUM SILICATE (TALC SOAPSTONE)—ALUM—ALUMINIUM SILICATE (CHINA CLAY)—ZINC SULPHIDE—ZINC CHLORIDE—ZINC SULPHATE—ZINC BORATE

**Magnesium Chloride,** $MgCl_2$.—**Occurrence.**—Naturally in sea-water and as double salt in carnallite, $KCl_2MgCl_2$, in the Stassfurt mines.

**Preparation.**—On dissolving magnesium oxide in dilute hydrochloric acid and evaporating the solution, magnesium chloride is deposited as crystals.

**Properties.**—Very soluble in water, its taste is bitter. In medicine it is used as a purgative; it is more active than the sulphate of magnesia. [Absorbs moisture from the air—deliquesces.]

**Action of Magnesia on Plants.**—Magnesium salts are comprised amongst the alimentary substances indispensable to plants. Ch. Dassonville found that plants watered with solutions of magnesium chloride first suffered a retardation in their growth and sprung up more rapidly afterwards. Loew states that a certain amount of magnesia and lime is required in the soil to obtain a maximum crop. Goessel made artificial cultures to fix these proportions with various amounts of these two oxides, and found that growth was at a maximum when the media contained the lime and magnesia in the proportion of 0·4 to 1. Katayama is of the same opinion as Loew in regard to the presence in the soil of these two oxides; he believes the ratio CaO : MgO as 2 : 1 as the most favourable for plants. Möller found that the absence of magnesia in certain soils had a marked influence on the normal evolution of a plant. The pine, for example, suffers and its leaves turn yellow at their extremities if it grows in a soil too deficient in magnesia. It then suffices to water the tree with a solution of sulphate of magnesia, or of chloride of magnesia, to re-establish the normal green coloration of the leaves. The analysis of yellow leaves compared with those of a normal green gave in the first case 0·279 per cent., in the second case 0·607 per cent. magnesia. Towards strong doses in the soil plants behave very differently. Steglich studied the action of magnesium chloride on plants by watering alternately with a solution of 30 and 15 per cent., and at the end of his investigations prepared the table on the following page.

Hitchcock and Carleton tried the action of magnesium chloride on rust of cereals. They found that a 1 per cent. solution prevented the germination of the uredospores of *Puccinia coronata*, Corda, after steeping for twenty-seven hours.

**Use.**—In strong doses magnesium chloride may be used to replace green vitriol to destroy charlock in cereal crops; it may act at the same time as a manure. Trials made up to now with a 20 per cent. solution, at the rate of 35 gallons per acre, have given good results. As a manure, it is recommended in pine nurseries to cure the yellow leaves of the pines which show a deficiency of magnesia in the soil.

**Magnesium Sulphate.**—$MgSO_4,7H_2O$.—**Preparation.**—By evaporating the waters of certain springs in England, Bohemia and British Columbia. It is obtained more readily by attacking dolomite by hot dilute sulphuric acid; a mixture of insoluble sulphate of lime is formed and soluble sulphate of magnesia which is separated by filtration.

TABLE XX.—*Showing the Effect of* 30 *per cent. and* 15 *per cent. Solutions of Magnesium Chloride on Plants* (*Steglich*).

| Crop. | 30 per cent. Solution. | 15 per cent. Solution. |
|---|---|---|
| Grain . . . | Suffered slightly | Did not suffer at all |
| Beet . . . | Did not suffer | Did not suffer |
| Potatoes . . . | Killed | Killed |
| Peas . . . . | Killed | Unattacked |
| Trefoil . . . | Suffered slightly | Unaffected |
| Lupins . . . | Strongly attacked | Slightly attacked |
| Mustard . . . | Killed | Destroyed |
| Charlock . . . | Slightly damaged | Insensitive |
| Sorrel . . . | Unaffected | Intact |
| Horse-tail . . | Suffered slightly | Unaffected |

**Properties.**—Magnesium sulphate crystallises with 7 molecules of water; 100 parts of water dissolve 26 parts of calcined magnesium sulphate at a temperature of 0° C. and 72 parts at 100° C. It possesses a bitter taste and is generally used in medicine, in which it is administered as a purgative. In the vegetable economy it plays the rôle of magnesium chloride, that is to say, dissolved in small amount in distilled water it is capable of prolonging the growth of plants; when the plant is strengthened it becomes indispensable to it. Experiments show that magnesium sulphate can render the same service as plaster in agriculture.

**Use.**—This product may be used to combat charlock in grain crops in the same way as magnesium chloride. Magnesium sulphate was recommended in 1852 to combat an insect injurious to beets termed—

*Atomaria linearis*,[1] Steph.—Kuhn recommends to combat this insect to immerse the beet-seed before sowing for twenty minutes in a steep of 5 per cent. of sulphate of magnesia and 1 per cent. carbolic acid. Although of an efficiency which is highly contested, followers of this practice include responsible experts (Marek, Pagnoul).

*Peronospora viticola*, de By. (mildew of the vine).—Solutions of magnesium sulphate act on the spores of this fungus, but they are not so poisonous as the salts of copper, so the experiments of Sbrozzi on diseased vines gave only very imperfect results.

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[1] ATOMARIA LINEARIS.—Coleoptera, 1 millimetre in length, with finely dotted elytra. The perfect insect appears at the moment of the germination of beet seed. It attacks the subterranean portion of the seedling and destroys it.

**Magnesium Bisulphite,** $MgH_2(SO_3)_2$.—**Preparation.**—By treating magnesia stirred up in water with sulphurous acid.

**Use.**—*Botrytis cinerea*, *Monilia frutigena*,[1] *Coniothyrium diplodiella*.[2]—Istvanffi found that bisulphite of magnesia had the same action on spores of these fungi as calcium bisulphite, of which an 0·5 per cent. solution acted in the same conditions eighteen times more energetically than a 10 per cent. solution of Bordeaux bouillie. He advises the use of a 0·4—0·5 per cent. solution of bisulphite of lime or magnesium to combat these fungi, a dose which can be increased to 1 per cent. without drawback.

**Silicates of Magnesia.**—**Occurrence.**—Two natural silicates may be used against plant diseases; they are steatite, $3SiO_2,2MgO_2$, talc, $5SiO_2,4MgO$. These two compounds are widely distributed in nature.

**Properties.**—The silicates of magnesia are neutral, inactive bodies insoluble in water. Owing to their fine division [and unctuosity] steatite and talc show a very great adherence to plants.

**Use.**—Their extreme fineness and lightness render steatite and talc highly appreciated for assuring to anticryptogamic substances a perfect distribution on diseased plants. These two silicates, therefore, enter into the composition of a large number of powders. Their rôle is to dilute the active principle.

*Uncinula americana*, How.—One of the chief uses of talc is in the *Poudre fonta* used against oidium and consisting of talc 90 per cent., sulphur 10 per cent.

*Peronospora viticola*, de By.—Steatite and talc are the most appropriate substances for the preparation of copper powders used to combat mildew. Sulpho-steatite consists of talc and blue vitriol. The powder Fostit made at Antwerp contains 90 per cent. of talc and 10 per cent. of blue vitriol. These two preparations are those most used, as owing to their lightness they penetrate vines better than any other preparation.

*Botrytis cinerea*, Pers. (grey rot of the vine).—The powder which has been most successful against this disease is that used by Dr. Baretto, on the advice of the Baron de Chefdebien. It consists of talc 92 per cent., sulphate of alumina 3 per cent., sulphate of lime 4 per cent., green vitriol 1 per cent. This mixture should be applied by copious dusting before and after flowering if it be desired to remove mould; if it be desired to arrest the grey rot it is necessary to apply this treatment every ten to twelve days after the disease appears. Talc does not play any active rôle in this preparation; the active agent is the sulphate of alumina; the sporicidic property in this special case is superior to that of blue vitriol. But the mechanical action of the talc must play an important part in this preparation, as Jean Burnat has obtained as excellent results as Baretto with the following preparation which did not contain sulphate of alumina: cement 20 per cent, soapstone 30 per cent., hydraulic lime 50 per cent. Burnat uses this mixture in copious powderings after previously moistening the diseased vines with a solution of soft soap. These two preparations are the only ones which, with that of Sokolnicki, have given satisfactory results in the treatment of grey rot of the vine.

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[1] MONILIA FRUTIGENA (brown rot of stone fruits).—This fungus causes great ravages, especially in America, in peach nurseries. The disease is characterized by the browning of the fruit, the flesh of which shrivels up, becomes as hard as horn, mummifies, and finally only forms a hard layer round the stone.

[2] ROT.—WHITE, PALE, LIVID. *Coniothyrium diplodiella*.—This fungus is a parasite of the grape, which may in certain cases do considerable damage. The *Coniothyrium* invades the stalk of the grape shoot and the sheath of the grapes. The latter change colour, become livid brown, and soften, and then wither, turning an earthy colour. On the skin of the dead grapes there form small globular conceptacles which give them a shagreen appearance.

**Alum,** $Al_2,3(SO_4)K_2SO_4,24H_2O$.—**Preparation.**—Ordinary alum is a double sulphate of alumina and potash. To prepare alum pure clays are calcined in a reverberatory furnace and then pulverized and mixed with 40 per cent. of sulphuric acid, 52° Bé. The mixture is kept for several days at a temperature between 60° and 80° C., at the end of which time the silica is deposited; the alumina is dissolved as sulphate of alumina, which, decanted and mixed with sulphate of potash, produces crystals of alum in the form of regular octahedra.

**Properties.**—Alum is a colourless salt of a sweet and astringent taste, much more soluble in hot water than in cold. Alum solutions have a slight acid reaction.

**Action of Alum on Plants.**—The vine does not stand this product and dies if it be watered with a 5 per cent. solution of alum (Mouillefert).

**Action of Alum on Fungi.**—Kuhn examined the action of an alum solution on the diseases of cereals produced by the fungi *Ustilago* and *Tilletia.* After fifteen hours' action on the spores some were still capable of germinating. According to the laboratory tests of Ravaz and Guirand aluminium sulphate has a decided action on *Botrytis cinerea.* This action is more evident than that of blue vitriol, which is almost nil; whilst, according to Millardet, the spores of *Peronospora viticola* are killed by a solution of 3 in 10,000,000, those of *Botrytis cinerea* still develop in a solution of 3 in 1000 of blue vitriol.

**Action on Insects.**—Alvood found that a 3 per cent. solution and even a 9 per cent. solution does not kill cabbage grubs and lice. Neither does it kill the larvæ of the gooseberry saw-fly, *Ptereneus ribesii.*

**Use.**—*Botrytis cinerea* (grey rot of the vine).—Amongst the substances recommended to combat this fungus two preparations have been recommended and given good results; they both contain alum or sulphate of alumina. Sokolnicki's contains 20 per cent. alumed plaster [alumed plaster is obtained by adding 10 per cent. of alum to plaster beaten up with water and reheating it], that of Baron de Chefdebien 3 per cent. of aluminium sulphate. [The composition of both these mixtures has been given under calcium bisulphite and talc.] The two compositions were successfully used in Brazil and in the department of the Gironde, and their efficacy is undoubted, yet De la Bathie got no result by using a bouillie containing 0·5 of alum or sulphate of alumina and a little lime.

*Schizoneura lanigera,* Hausm. (woolly aphis).—Alum has been advised and frequently used for a very long time to combat this pest. Some results were got by a solution of 2 per cent. alum and 4 per cent. soda. Mohr advises a mixture containing 4 per cent. alum and 5 per cent. amylic alcohol (fusel oil) to destroy larvæ without down at the moment they are hatched from the winter egg [Nov.–Dec.]. But this mixture does not seem to kill eggs and adults. No appreciable result was got in recent trials made with concentrated solutions of alum alone.

**Silicate of Alumina** (clay).—**Occurrence.**—Pure silicate of alumina is known as kaolin (" china clay ") and " plastic clay "; mixed with carbonate of lime it forms potters' clay.

**Properties.**—Mixed with water, clay forms a supple, plastic, and unctuous paste.

**Use.**—In virtue of its special properties clay is used to guarantee the bark of trees against the bites of leporides or to asphyxiate xylophagous insects. For this purpose it is mixed with cow-dung and often with ox-blood or curdled milk. The following insects *inter alia* may be got rid of in this way :—

*Agrilus sinuatus*,[1] Ol. (burn-cow of the pear-tree).—To prevent the burn-cow from laying its eggs the trunks and branches of the trees are coated with potters' clay; to fight the larvæ and asphyxiate them in their burrows the whole of the bark must be coated with a mixture of potters' clay and cow-dung, and a band of cloth applied on this coat. Goethe found this treatment good. It can also be used against scolytes and bostriches such as *Scolytus pruni*, Ratzeb. (scolytus of the plum), *Scolytus rugulosus*, Koch (rugose scolytus), *Tomicus dispar*, Fbr. (bostriche different). To protect fruit trees against these three insects the trunk and branches are coated with a mixture of lime and clay.

*Coccides.*—To kill coccides a very old method consists in coating the trees invaded with the following composition : Clay, soot, cow-dung, sulphur beaten up with water to a pasty consistency.

*Rabbits.*—To prevent rabbits from nibbling the bark of fruit trees these are coated at their base with one of the following preparations : (1) Potters' clay 2 lb., cow-dung 2 lb., ox-gall 1 lb., bullock's blood 1 lb. This mixture is stirred up with purin to a pasty consistency. (2) Potters' clay 2 lb., curdled milk 2 gallons, blood 2 gallons, purin 6 gallons. (3) Asafetida 1¼ lb., blood 8 gallons, with sufficient cow-dung and clay to give a smooth paste. The odour of these coatings being very repugnant to rabbits keeps them at a distance.

**Zinc Sulphide,** $ZnS$.—**Preparation.**—By adding hydrogen sulphide to a solution of zinc sulphate. The white precipitate is filtered and washed.

**Properties.**—Zinc sulphide is insoluble in water.

**Use.**—Fairchild used a zinc sulphide bouillie, made by precipitating sulphide of zinc by a solution of liver of sulphur against (1) *Phyllosticta sphæropsidea*, E. and E. (spots of the leaves of the chestnut), and against (2) *Entomosporium maculatum* (spots of the leaves of the pear-tree). Result in (1) appreciable, in (2) nil.

**Zinc Chloride,** $ZnCl_2$.—**Preparations.**—By dissolving zinc clippings [or zinc scrap] in dilute hydrochloric acid. By evaporating the solution the anhydrous salt is obtained.

**Properties.**—Zinc chloride is a white deliquescent solid soluble in water in all proportions; exposed to air it liquefies rapidly.

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[1] Agrilus sinuatus, Viridis or Piri (green burn-cow).—Insect 1 centimetre long, 2 millimetres wide. Its colour is copper-green. Common insect, which attacks a large number of forest and fruit trees, chiefly oak, beeches, and pear-trees. The larvæ burrow in the wood and bark, then towards the second year of its evolution it pierces a hole in the wood, where it becomes a grub.

**Action on Fungi.**—Zinc chloride behaves like zinc sulphate (Wuthrich). All remarks made on zinc sulphate (farther on) apply to zinc chloride. Tried comparatively against copper compounds on the *Peronospora viticola*, de By., by Sbrozzi, its effect was inferior to blue vitriol. By the use of a 1 per cent. solution the uredospores of *Puccinia coronata*, Corda, are checked in their development [Hitchcock and Carleton].

**Zinc Sulphate,** $ZnSO_4,7H_2O$ (white copperas).—**Preparation.**—By roasting crude zinc sulphide at a low temperature a mixture of zinc and iron sulphates is formed which is dried and calcined to decompose the sulphate of iron. The mass is then lixiviated with hot water, filtered, and the solution of zinc sulphate evaporated to crystallization. Other processes depend on the action of sulphuric acid on zinc or its oxide.

**Properties.**—Zinc sulphate forms colourless crystals with a bitter styptic taste. It dissolves in 2⅓ times its weight of water at 15° C. and in its water of crystallization at 100° C.

**Action of Zinc Sulphate on Plants.**—Sulphate of zinc shares the property that the sulphates of iron, copper, and other salts have of stimulating the growth and vitality of the plant if absorbed in small doses and of being poisonous in large doses. Raulin, Richards and Ono examined this property of zinc sulphate on *Aspergillus niger*, *Penicillium glaucum*, and the algæ *Protococcus* and *Chroococcus*, *Stigeoclonium* and *Hormidium*, and determined the stimulating action of zinc salts. As soon as the dose is higher than that required for stimulation, these salts retard or prevent the formation of spores. The dose required to stimulate algæ is much less than that required to stimulate fungi. Kanda made similar trials with Pisum and found that the stimulating action of zinc sulphate is produced when the nutritive solutions do not contain more than 0·00000015 to 0·0000030 per cent. of zinc sulphate. Nobbe, Bässler, and Will found that peas and maize died in three days if the nutritive medium in which they grew contained 1 per cent. of zinc as nitrate of zinc. This poisonous action is much less pronounced and sometimes does not occur in darkness. Many plants, chiefly conifers, bear without injury 1 per cent. sulphate of zinc without dying but afterwards show great defects in growth. König found in fact 2·78 per cent. of zinc in the ash of beech and maple stunted by slow poisoning by zinc. There even exist plants which seek media rich in zinc minerals for their development; these are *Viola lutea* (*forma calaminaria*) and *Thlaspi alpestre*. Zinc salts behave like blue vitriol and other poisonous salts in nutritive solutions where the roots are in direct contact with the soluble salts; these are poisonous in comparatively small doses because the plants readily absorb them in large quantities, but the same plants cultivated in the soil bear strong doses because they are there converted into insoluble salts, the roots of which only absorb small quantities incapable of producing a poisonous effect. Haselhoff and Gössel found that the presence of 0·235 per cent. of zinc oxide in a soil does not injure vegetation but that zinc sulphate in the same dose calculated as oxide was poisonous.

**Action of Zinc Sulphate on Cryptogamic Parasites.**—According to comparative experiments by Wuthrich zinc sulphate acts like green vitriol, and in the same doses as the latter destroys the spores of different fungi. It is thus, like green vitriol, 10 times less poisonous than blue vitriol and 100 times less active than mercuric chloride, the three salts being used in solutions containing their chemical equivalents.

*Phytophthora infestans*, de By.—The conidia treated by a 0·0143 per cent. solution are weakened, and after fifteen hours in a 0·143 per cent. solution destroyed. The zoospores of this fungus are stunned in a minute in a 0·143 per cent. solution and killed in fifteen hours.

*Peronospora viticola*, de By.—The conidia are weakened by a 0·00143 per cent. solution. Their growth is stopped by 0·0143 per cent. solution.

*Puccinia graminis*.—The uredospores and the æcidospores are arrested in their growth by the action of a 0·143 per cent. solution.

*Ustilago carbo* (smut).—The growth of the conidia is retarded by a 0·143 per cent. solution, but they are not killed by a 1·430 per cent. solution. According to Madame de Ponsard, spores immersed for four hours in a 1 per cent. solution partially germinated.

*Claviceps purpurea*, Tul. (ergot).—The conidia are not killed by a 1·43 per cent. solution.

**Use.**—*Peronospora viticola*, de By. (mildew of the vine).—Following experiments by Wuthrich who showed that the action of zinc sulphate on the spores of this fungi is evident though comparatively weak, Guocdenovic made experiments with a 1·0—1·5 per cent. zinc carbonate with a bouillie made by mixing solutions of zinc sulphate and sodium carbonate. The results were not comparable with those obtained by the Burgundy bouillie nor the Bordeaux bouillie. Passerini's experiments also showed that a bouillie with a zinc sulphate basis had no curative action, like copper bouillies.

*Phylloxera vastatrix*, Planch.—Mouillefert completely destroyed the phylloxeras on an infested root by steeping it in a 1 per cent. solution of zinc sulphate.

**Borate of Zinc,** $ZnB_4O_7$.—**Preparation.**—By precipitating a solution of zinc sulphate by [a solution of] borax. On mixing the concentrated solutions a gelatinous precipitate is obtained.

**Use.**—Galloway examined on *rust* the effects of a bouille made by precipitating 133 grammes of zinc sulphate by a concentrated solution of 133 grammes of borax and making the whole up to 15 litres. Oats and summer wheat treated on 6, 16, 20 June and 5 July were free from rust and gave an excellent yield in grain, 284 grammes against 240 grammes on the check plot of the same size. He regarded this preparation as efficient against rust.

## CHAPTER X

### IRON PEROXIDE—IRON BOUILLIES—IRON CHLORIDE—GREEN VITRIOL —POTASSIUM FERROCYANIDE

**Hydrate of Sesquioxide of Iron (Ferric Hydrate),** $Fe_2(HO)_6$.—**Preparation.**—By precipitating a solution of sulphate of iron (green vitriol) by caustic alkali or by milk of lime.

$$FeSO_4 + 2KOH = Fe(OH)_2 + K_2SO_4.$$
$$FeSO_4 + Ca(OH)_2 = Fe(OH)_2 + CaSO_4.$$

The hydrate of the protoxide of iron, ferrous hydrate, a greenish-white precipitate which is first formed, oxidizes afterwards in contact with the air, and is converted into hydrate of sesquioxide of iron, ferric hydrate, which is yellowish-brown.

$$2Fe(OH)_2 + H_2O + O = Fe_2(OH)_6.$$

The bouillies used against plant diseases were made from 1—15 lb. of green vitriol and ½—8 lb. of quicklime per 10 gallons of water. Their preparation is similar to the Bordeaux bouillie. The green vitriol is dissolved in 5 gallons of water, and the quicklime made into milk of lime is run with 5 gallons of water into the green vitriol solution with suitable stirring. The bouillie should have a slight alkaline reaction.

**Properties.**—The ferric bouillie has the physical properties of the Bordeaux bouillie and behaves like the latter, both as to its adherence and the solubility of its precipitate by atmospheric agents.

**Action of the Ferric Bouillie on Plants.**—There exists between the iron bouillie and sulphate of iron (green vitriol) the same relation as between Bordeaux bouillie and sulphate of copper (blue vitriol). The sulphuric acid of the sulphate of iron being neutralized is in an inert and insoluble form; the sulphate of lime does not scorch the leaves like green vitriol solutions exceeding 2 per cent. But the hydrate of sesquioxide of iron engulfed in the sulphate of lime, and in an excess of lime, has not however such a rapid action on the chlorotic condition of the plants treated as solutions of green vitriol. Dufour has shown that iron placed in contact with the plant in this slightly soluble form is none the less absorbed wherever the leaf is touched by the ferruginous bouillie. Chlorotic plants after several sprayings with this bouillie show green places at all points of contact. Nevertheless, the effect of these bouillies is *nil* if a strong dose of sulphate of iron be not used. Whilst 1 per cent. solutions of ferrous and ferric salts produce a stimulating effect on the plant, it requires 3—15 per cent. of hydrated oxide of iron to produce the same effect, and it is necessary to apply these bouillies in sprayings several times a year. Lagarrique recommends to apply them every fifteen days. Several scientific observers have imagined that the stimulating effect of copper bouillies was to be attributed to the sulphate of iron present in greater or less amount in commercial sulphate of copper. In their opinion pure copper sulphate free from iron would have no salutary effect on the plant and could not be absorbed by it without injuring its health. The mixed bouillies of sulphate of iron and sulphate of copper recommended to accentuate the stimulating effect of Bordeaux bouillie are :—

*Pellegrini's*, 1 lb. of blue vitriol, 1 lb. of green vitriol, 1 lb. of quicklime in 10 gallons of water. *Aderhold's*, 19 lb. of blue vitriol, 1 lb. of green vitriol, 20 lb. of quicklime in 100 gallons of water. *Sorauer's*, 19½ lb. of blue vitriol, ½ lb. of green vitriol, 20 lb. of lime in 100 gallons. Guocdenovic, who examined the action of these bouillies compared with those of pure sulphate of copper, found they were in no way superior as stimulants. One cannot understand, in fact, how a copper bouillie containing only 0·1 –0·05 per cent. green vitriol as hydrated oxide of iron can produce any stimulating effect when it is necessary to use 3 per cent of this oxide to produce the same effect with a ferric bouillie.

**Action of Ferric Bouillies on Fungi.**—The hydrated oxide of iron has no pronounced toxic action on the spores of fungi, and cannot in any case replace the hydrated oxide of copper in the struggle against cryptogamic disease. Although green vitriol be ten times less toxic for plants and fungi than blue vitriol, these relations do not exist between the corresponding iron and copper oxides. The numerous experiments to replace the costly cupric bouillie by bouillies with a hydrated oxide of iron base have given no result in the struggle against plant diseases due to parasitic fungi.

*Phytophthora infestans*, de By. (potato disease).—Iron bouillies have been more especially tried against this disease as substitutes for Bordeaux bouillie. Giltay's experiments with a bouillie of 1 per cent. green vitriol and ½ per cent. of lime gave negative results. Sempotowsky tried stronger bouillies, but they had no more effect in diminishing or preventing the potato disease than the 1 per cent. solution. Steglich also points out the bad effects on potatoes by treatment with iron bouillies containing 2—4 per cent. of sulphate of iron.

*Gloeosporium ampelophagum*, Sacc. (grape rot).—Pellegrini obtained very good results in overcoming this disease with a bouillie consisting of 1 lb. of blue vitriol, 1 lb. of green vitriol, and 1 lb. of lime in 10 gallons of water.

**Iron Chloride,** $Fe_2Cl_6,12H_2O$.—**Preparation.**—By dissolving iron in *aqua regia* or by passing a current of chlorine into a solution of protochloride of iron (ferrous chloride). The solution concentrated by boiling yields on cooling orange red crystals of ferric chloride.

**Properties.**—Very soluble in water. Its solutions coagulate blood and act as hemostats in medicine.

**Use.**—Galloway found a 1 per cent. solution sprayed every ten days on wheat fields preserved them against rust. The treated plot showed no rust. The check plot showed twelve plants attacked. This action, which greatly resembles the action of soluble salts of copper, is apparently only due to the exceptional vigour of the cereals due to this treatment. Moreover, Hitchcock and Carleton have shown that a 1 per cent. solution of perchloride of iron can only interfere slightly with the vitality of the spores of *Puccinia coronata*, Corda (crown rust of oats), and Wuthrich has proved that it requires a 10 per cent. solution of perchloride of iron to kill the uredospores of *Puccinia graminis*, Pers. (linear rust). At the same strength as the persulphate of iron, ferric chloride is directly assimilable by the leaf and acts as a powerful stimulant of the vital functions of the plant. As a tonic, perchloride of iron may be of use in the struggle against the diseases of plants, but it cannot be ranked as an anticryptogamic substance capable of killing the spores of fungi.

*Chlorosis.*—Stevignon made comparative trials with perchloride of iron and green vitriol, and found that the action of the perchloride was much more rapid than that of the sulphate. He obtained the best results by making incisions in the bark of the stocks, and coating the wounds with a 40 per cent. solution of perchloride of iron; fifteen days after treatment the chlorotic vines were quite green. Comparative trials with hydrochloric acid itself have shown that it is the iron which is the active element and not the hydrochloric acid.

**Sulphate of Iron,** syn. **Green Vitriol,** $FeSO_4,7H_2O$.—**Preparation.**—(1) By roasting iron pyrites and lixiviating the product. (2) By slow oxidation in the air of pyritic shale. (3) By dissolving iron turnings [or scrap iron] in dilute sulphuric acid. By concentrating the solution to 40° Bé., it yields green crystals responding to the formula $FeSO_47H_2O$.

**Properties.**—*Solubility*, 100 parts of crystallized green vitriol dissolved in 143 parts of water at 15° C., and in 30 parts of water at 100° C. To prepare solutions of green vitriol it is best to use boiling water; they must then be kept in closed vessels, for the salt is readily converted into a slightly soluble basic sulphate of sesquioxide of iron in contact with the air; green vitriol has a styptic, astringent taste.

**Action of Green Vitriol on Green Plants.**—Iron is invariably present in all green plants, but often in very small quantity. As to its distribution in the plant, it may be said to be present more especially in all the green parts, without being, however, entirely absent in other parts of the plant. Iron may be considered as necessary to plants as to man and animals. Its absence produces a pathological condition known as *chlorosis*. Culture experiments have shown that the plant cannot develop itself normally in absence of iron. The necessary quantity is very small, and 2—5 milligrammes suffice for a cereal plant (Knop). Sachs induced artificial chlorosis by cultivating plants in a soil in which iron was excluded. Experiments made in nutritive solutions show that the seed may germinate and the young plant grow normally in the absence of iron; the small quantity of iron present in the seed amply suffices in the beginning to allow a normal growth, but later on a fresh portion of iron becomes indispensable or the plant gets into a bad state. Knop proved that the amount of iron in a gland was sufficient to prevent chlorosis of the young oak for two years. The plants which succeed best are those treated with a 0·15 per cent. solution of green vitriol; a stronger dose than 0·2 per cent. is often injurious. The absence of green in plants deprived of iron has given rise to the idea that iron takes part in the formation of that colour, but we are far from knowing exactly what is its rôle in the formation of chlorophyll. Formerly it was believed that iron entered into the composition of chlorophyll as in the hæmoglobin of the blood, but this opinion is not entertained at the present time. The analysis of purified chlorophyll and the demonstrations of investigators later prove, in fact, that iron does not enter into the chemical composition of the green parts of plants. Certain discoveries, however, lead us to suppose that there exists along with chlorophyll substances of analogous composition containing iron. Iron is not only indispensable to the normal formation of chlorophyll, but it has a favourable action generally on the life of the plant. Millardet and Knop believe that, like blue vitriol, green vitriol acts without penetrating the leaf, for they were not able to find ponderable quantities in the organs cured. Of a contrary opinion Dufour describes the absorption of these salts by the surface of the leaf, and Weiss and Wiesner have shown that iron which enters into the plant exists there in organic combination which may have escaped Millardet and Knop. Frank, Kruger, and Vedrosi regard green vitriol as equal to blue vitriol as a stimulant of the plant, and believe that a very small dose suffices to produce a visible and salutary effect. These two salts seem to act in quite the same manner on plants with this difference, that copper salts possess an action ten times stronger than iron salts taking into account their different chemical equivalent. Shrubs which annually undergo the classical treatment with Bordeaux bouillie, likewise those which are treated with solutions of green vitriol, acquire a greatly increased vitality which increases assimilation and a longer vitality which enables trees to preserve their leaves in autumn much longer than those untreated. These facts prove that iron is the active chemical agent in the formation of chlorophyll, stimulating its functions, and in that way also it becomes the indirect provider of starch, sugar, and cellulose for the plant. Without iron, on the other hand, the plant eventually dies because assimilation of carbonic acid becomes impossible. The rôle of iron therefore seems analogous to that of potassium, the absence of the latter element also inducing the anæmia of plants. The substitution of iron for potassium according to Griffiths' experiments would be very advantageous in the struggle against the cryptogamic diseases of plants. Potash is very favourable to the development of fungi, whilst green vitriol is injurious. The substitution of green vitriol for potassic manures whilst giving the same physiological results would have the effect of circumscribing the cryptogamic diseases of plants. Desjardin had already observed the great resistance of plants treated with green vitriol to disease. Chavie-Leroy certifies that the simultaneous use of green vitriol and gypsum preserves grain crops from rust and laying; it diminishes ergot, the fall of the flower of the vine, stops the canker of apple and pear trees, and causes the gum of stone-fruit trees to disappear. Like gypsum, green vitriol used in the soil acts on the latter from a physical and chemical point of view. Boussingault agrees (1) that it oxidizes the organic matter of humus and hastens its decomposition; (2) that it fixes ammonia in the soil; (3) that it aids the plant to absorb the phosphoric acid in the soil. Thenard and Joulie state that phosphate of lime is converted in the soil, in contact with oxide of iron, into phosphate of protoxide of iron soluble in water charged with carbonic acid; the ferric phosphate formed would afterwards be reduced by the organic matter. Knop was convinced of the action of iron as a vehicle for phosphoric acid. Like gypsum, green vitriol effects a radical change in the soil by the decomposition of the insoluble minerals which contain potash. Green vitriol forms an equivalent of a soluble potash salt and thus renders the richness of the soil available for the plant. It follows that green vitriol, having always a beneficial action on crops, is thus capable of increasing the yield and that chiefly as regards plants to which potash is necessary. Where carbonate of lime is the cause of the chlorosis, green vitriol has a very intense ameliorative action and must be used in large doses. It acts on the soil by destroying the soluble carbonate of lime and on the plant by revivifying the juices and imparting to them new vigour, for the excess of carbonate of lime exhausts the acid juices of the root which then cease to act. It follows from Vernet's experiments that the use of green vitriol in 5 per cent. solution with 5 per cent. of sulphuric acid gives still better results; this acid decomposes the carbonate of lime and enables the green vitriol to come in contact with the roots as such. Chlorosis was in this way made to disappear in soils containing ·19—·25 per cent. of carbonate of lime. As to the form under which the iron ought to be applied to the roots it is not definitely settled, neither do we know what salt of iron is most easily assimilated by plants and under what form the iron is conveyed the most easily from cell to cell. Ferrous salts [of which green vitriol is one] are always, it is supposed, converted into ferric salts in contact with the oxygen of the air in the soil. However, many facts appear to contradict this opinion; the most different ferrous and ferric salts are capable of remedying the pathological condition produced by a deficiency of iron. These salts spread by copious spraying on the roots act before the ferrous salts (green vitriol, etc.) can have had the time to be converted into ferric salts. If the ferric salts are more active, on the other hand, the ferrous salts render the same service in a longer time. It must be mentioned that green vitriol ferrous sulphate must be used in a much more dilute condition than ferric sulphate. The form most favourable for artificial cultures is the phosphate of iron which the roots assimilate after rendering it soluble. The following observation speaks in favour of the absorption of iron under the form of ferrous salts: plants which live in marshes, rich in green vitriol, possess great accumulations of iron as ferric-oxide in certain of their organs. (*Trapa natans* contains in its ash 68·6 per cent. of ferric oxide.) These deposits cannot be otherwise explained than by the precipitation by oxygen of soluble ferrous salts being conveyed through the plant and so converted into insoluble ferric salts. According to Mokrzecki it is possible that green vitriol may be absorbed by the plant, and conveyed by the sap. The rapid and radical cure of chlorosis by injection into the trunk of dilute solutions of green vitriol which in no way affect the good working of the circulation is a convincing proof.

It follows, therefore, that iron may be supplied to the plant under any form, and that ferric salts as well as ferrous, organic and inorganic salts of iron are capable of curing chlorosis. (Gris has shown that the sulphate, tartrate, malate, and acetate of iron in the dose of 0·5 per cent. when they are used in sprayings on the leaf produce an analogous effect.) It must be admitted, in fact, that the roots can convert the iron into a compound fit to circulate through the organs of the plant, and to produce the remarkable physiological effects described above. If a certain dose be exceeded the iron becomes injurious, if given in excess it is mortal. Different plants behave very differently with the same dose of iron. Whilst certain plants suffer with a dose of 0·05 per cent. of green vitriol in an artificial culture medium, trees may support injections of a 0·25—0·5 per cent. solution of the same substance. The injurious action of green vitriol depends greatly on the nature of the plant to which it is applied. Aqueous plants very fond of water are much more sensitive than plants not fond of water. Mosses, for example, feel the action of green vitriol much more than cereals. A strong dose of green vitriol has a specially injurious action on the vital functions of the plant; thus Mayer found that, used for grain crops, it hindered the grain from forming in the ear.

TABLE XXI.—*Showing the Number of lb. of Green Vitriol which Wheat, Rye, Barley, and Oats, respectively, can bear per* 1600 *lb. of Soil.*

| Grain crop. | Lb. of green vitriol. |
|---|---|
| Wheat | 4 |
| Rye | 10 |
| Barley | 20 |
| Oats | 20 |

Whilst barley is unable to form its grain if the dose of green vitriol contained in the soil is above that given in Table XXI, oats resist better. The injurious action of green vitriol is explained by the fact that in presence of tannins and certain other analogous products it is readily decomposed into insoluble organic compounds and sulphuric acid. The latter causes at a certain concentration the corrosion of the cellular tissue and disturbs the osmotic phenomena of the cell-walls. Experiments have shown that 60 kilogrammes per hectare (½ cwt. per acre) may always be used with advantage, whilst a dose of 250 kilogrammes per hectare (2 cwt. per acre) was often injurious.

**Action of Green Vitriol on Fungi.**—Iron is not only necessary to green plants, but a small quantity of this product would also seem to be required by parasitic plants with no chlorophyll. The latter are, however, more sensitive to green vitriol, which, like blue vitriol, is often a violent poison for them. As to spores it has been shown that the injurious action is connected with the penetration of the green vitriol through the exterior membrane. If this penetration does not occur the action is *nil*, if it occurs vitality is arrested. Iron, like copper, may be found in the interior of the spores by means of certain reagents. To determine if green vitriol has penetrated the spores, these, after steeping in the green vitriol solution, are washed for fifteen minutes, then they are placed in a bath of yellow or red prussiate of potash and a little hydrochloric acid. If the iron has been absorbed the spore becomes blue. Wuthrich found this absorption in all cases where the spore was dead after immersion in vitriol. According to the experiments made up to now on fungi, green vitriol acts identically with blue vitriol, which, however, is the more energetic. Wuthrich concludes that the doses of green vitriol and of blue vitriol which produce the same action on the spores of different fungi are proportional to the chemical equivalents of these salts, green vitriol being ten times weaker.

The following are the amounts of green vitriol and blue vitriol required to stop the growth of spores :—

TABLE XXII.—*Showing the Strength of Solutions of Blue and Green Vitriol Required to Kill Spores of*

| | Green vitriol, per cent. | Blue vitriol, per cent. | |
|---|---|---|---|
| *Phytophthora infestans* | 0·139 | 0·0125 | Wuthrich |
| *Peronospora viticola* | 0·139 | 0·0125 | ,, |
| *Ustilago carbo* | 1·39 | 0·125 | ,, |
| ,, ,, | 5·00 | 0·5 | Boiret |
| *Puccinia graminis* | 1·39 | 0·125 | Wuthrich |
| *Claviceps purpurea* | 13·9 | 0·0125 | ,, |

From the above table spores have not the same resistance to green vitriol. Whilst some are very sensitive others are very resistant, and support doses poisonous to certain green plants. The quantity required to destroy some of them is so great that there can be no question of their destruction on the nurse plants by green vitriol, for the latter plants would be killed as well as the parasites. That is why blue vitriol can never be replaced by green vitriol in fighting the cryptogamic diseases of plants. When the parasites can be attacked without injury to the plant, green vitriol is an excellent cryptogamic; its use in the treatment of anthracnose is a striking example. Although green vitriol be less utilized in agricultural medicine than blue vitriol, its use against the cryptogamic parasites of our cultivated plants is a necessity in many cases. Where its action is not sufficient to destroy the spores of the fungi by imparting greater vigour to the plant, it enables it to contend more readily against its parasites. Galloway has shown that sprayings with green vitriol absolutely incapable of killing the spores of rust, nevertheless almost entirely eliminated this disease from the grain crop. The same applies to the *Claviceps purpurea* (ergot), a fungus reputed to have a very great resistance to green vitriol, the ravages of which may, however, be considerably diminished by spraying therewith. Each time that green vitriol has been used as a manure for cultivated plants, or sprayed thereon, improvement has resulted as well as a considerable diminution in diseased plants.

**The Action of Green Vitriol on Insects.**—Green vitriol has no action on hard-skinned insects, for it is not absorbed so long as the skin is intact. The mucous membranes, on the other hand, may absorb poisonous doses; taken through the mouth iron salts are violent poisons. Amongst mammals a small amount of iron salt may cause death by stopping the action of the heart. Ferric salts are more dangerous than ferrous salts, because they coagulate the soluble albumen and thus arrest the circulation of the vital liquids. Ferric salts ought, therefore, to be regarded as violent poisons. The action on insects does not make itself felt unless absorbed by the mouth, in eating the leaves sprayed with iron salts.

**Use of Green Vitriol.**—From time immemorial ferruginous manures were used to improve crops. The Romans knew the good effect of iron and utilized as a manure certain soils, rich in oxide of iron, still in use in Italy under the name of "Terra rosa." In Champagne, likewise, pyritic shales have been used in vineyards for centuries. In the North of France, Picardy, the Ardennes, Normandy, and in Flanders, there are used for the same purpose the ashes of Picardy which contain much iron pyrites. These are not only used to double the yield of meadows but also to strengthen cereals. Astonished at the results obtained by the use of these ferruginous manures, E. Gris tried to ascertain the cause. His experiments showed that the green vitriol formed by the slow oxidation of the pyrites in the soil was the active cause. He recommended green vitriol to improve crops and to contend against chlorosis. Further researches enabled the function to be explained and extended its use. Gradually it entered common use to contend against the cryptogamic diseases of plants. Green vitriol may be used in different ways; in cultivation on the large scale it is spread as crystals, or in 3—5 per cent. solution, by watering carts; it may also be sown by hand as a fine powder intimately mixed with dry earth. To cure trees of chlorosis and parasitic diseases, the incorporation of green vitriol in the soil may be replaced by spraying on plants or even by injection into the trunks of the trees. Used in that way the action of green vitriol is felt much quicker than when it is absorbed by the roots.

**Use of Green Vitriol as a Weed-killer.**—All plants being more or less sensitive to the action of green vitriol, it is evident that by using a determinate quantity of this salt all the plants which have a less resistance can be eliminated from a given crop. Thus grain crops possess a surprising resistance to this product, and it is possible to destroy all the weeds in a field of grain without injuring the crop. Steglich has treated different adult plants with a 20 per cent. solution of green vitriol and obtained the following results: Grain crops are not attacked; peas, trefoil, linseed, charlock suffer from this treatment; potatoes, beets, haricots, lupins are greatly damaged; mustard is killed. Stender confirms Steglich's results. He treated cultivated plants with a 15 per cent. solution of green vitriol by spreading it at the rate of 4 hectolitres per hectare (35·2 gallons per acre) and found no damage on cereals, blue lupin, red trefoil, colza, poppy, and carrot, but moderate damage on peas, flax, and serradelle (? saw wort); finally much damage on millet, rape, white mustard, potatoes, and beet. Twenty-five per cent. solutions of green vitriol destroy almost all weeds; however, horse-tails, comfrey, nettles, and carex resist perfectly. The action of green vitriol solutions is especially deadly to young plants when they have only three to four leaves; if the adult plants resist concentrated (15—20 per cent.) solutions, young plants cannot stand much smaller doses. Strong solutions of green vitriol are not, therefore, necessary when used rationally, and, as Dumont found, a 5 per cent. solution suffices in most cases, especially when it is a case of destroying young mustard. The older the plant to be destroyed the stronger should be the solution of green vitriol; thus mustard in flower requires a 10 per cent. solution, adult mustard a 15 per cent. solution. Gwallig recommends for the destruction of this plant a 7—10 per cent. solution. Linet agrees. To destroy charlock, Hitier estimates that 10 hectolitres of a 10 per cent. solution per hectare suffice (88 gallons per acre suffice). Weiss also recommends this same quantity, but of 10—15 per cent. strength. Schultz concluded after numerous tests that it was necessary to use 15 per cent. solutions, although young weeds already suffer with a 2—3 per cent. solution. It is necessary to apply this treatment when the plants have only three or four leaves; it is true that cereals suffer slightly when young even when only a 7 per cent. solution is used, but they soon revive and grow afterwards with increased vigour. To destroy young charlock and mustard 5—10 per cent. solutions suffice, but to destroy all weeds 15 per cent. solutions must be used. Wallflower requires a 10 per cent. solution in the beginning of vegetation. Before spreading green vitriol on a field the age and sensitiveness of the plant must be taken into account. It is best to proceed thus: The solution of green vitriol is conveyed to the neighbourhood of the field and sprayed by a spraying machine or a watering-cart. The best time to treat weed-infested fields is just before the weeds rise up into stems, *i.e.* when they have four to six leaves. It is well to spray in fine weather, which by concentrating the solutions on the surface of the leaves increases the effect. To free fields of grain chemically from charlock, advantage may be taken of the dew to spread finely pulverized green vitriol at the rate of 200—300 kilogrammes per hectare (176—264 lb. per acre). If rain intervenes after green vitriolizing, its effect is lessened or destroyed. But even in that dose and under that form green vitriol is not so efficient as a 4 per cent. solution of blue vitriol at the rate of 800—1000 litres per hectare (70—88 gallons per acre). A man is capable of vitriolizing a hectare (2½ acres) a day; 10 hectolitres (220 gallons) of green vitriol solution, that is to say, 100 kilogrammes (2 cwt.) of this salt suffice per hectare (88 lb. in 88 gallons per acre). There must be no hesitation in applying this treatment, which while freeing the fields from encumbering weeds supplies it with a new element as an aid to growth. From Steglich's comparative trials green vitriol has no advantage over such metallic salts as muriate of potash, nitrate of soda, and sulphate of ammonia, which whilst destroying weeds are good manures. However, we believe that green vitriol is superior to these salts by its anticryptogamic properties.

Maier-Bode states that the common garden poppy is very sensitive to a 13 to 20 per cent. solution of sulphate of iron, and, as a 15 per cent. solution has been found to do no permanent harm to the cereal crop when destroying charlock by this method, the British Ministry of Agriculture recommends that a solution of this strength might be tried. To prepare such a solution 60 lb. of powdered sulphate of iron must be dissolved in 40 gallons of water. For an acre of the cereal crop, 40 gallons of the solution should suffice.

**Destruction of Moss.**—1. *On Meadows and on Lawns.*—Mosses which invade all lawns, and diminish the yield of many meadows, may be readily destroyed by green vitriol. Their affinity for water is such that they absorb in large quantity the green vitriol distributed in solution. The extreme limits to employ per hectare are 250—500 kilogrammes of green vitriol (2—4 cwt. per acre). It is well to spread the distribution over several applications, especially when the meadow is badly choked up with moss. Noffray advises not to go beyond 100—150 kilogrammes per hectare (88–132 lb. per acre) in each of these applications. If green vitriol is used in crystals, it is necessary to choose fine weather to spread it after a strong dew, during or after rain. If green vitriol is used in solution in watering-carts, any time may be chosen; however, the best result would be obtained by applying the treatment after cutting the grass. Mosses infest poor and moist soil; after their destruction by green vitriol the cause of their presence should be obviated by manuring and draining [and liming].

2. *On Trees.*—To free the trunks of trees from mosses and lichens, which are so many refuges for parasites, they are scraped with the decorticator-moss-eradicator, then the trunk and branches are coated with a solution of green vitriol. The stronger the solution the better, but the strength of the green vitriol may be considerably reduced by adding a corrosive acid, such as sulphuric acid; in such conditions a 10 per cent. solution of green vitriol containing 2 per cent. of sulphuric acid acts as well as a 40 per cent. solution of green vitriol. By adding 2 per cent. of blue vitriol to this solution, the tree is freed from all spores of fungi.

3. *On Roofs.*—A 10 per cent. solution of green vitriol spread on moss-covered roofs completely destroys the moss. But green vitriol cannot be used where there are zinc gutters, for the latter will be corroded by contact therewith.

**Destruction of Dodder.**—Dodder is a plant without chlorophyll, which, like fungi, is more sensitive to the action of iron than green plants. But if the filaments of the young plant do not resist 2 per cent. solutions, on the other hand a 10 per cent. solution is required to kill the adult plants, which often kills or injures the nurse plant. Schribaux's tests have shown that dodder seeds, owing to their thick tegument, resist 20 per cent. solutions of green vitriol, and that even after steeping for fifty days their vitality is not lessened. Immersion in water for fifty days: 19 per cent. germinated. Immersion in 20 per cent. solution of green vitriol for fifty days: 12 per cent. germinated. Dodder specially invades trefoil and lucerne fields, plants equally sensitive to 10 and 20 per cent. solutions of green vitriol; needless to say the treatment should be applied before fructification and should not extend over the whole field. It suffices to treat the parts attacked. Stronger solutions of sure effect can thus be used. By sacrificing a few square yards of the crop the spread of the plague can be averted. The following is the best method of working: After mapping out the dodder spots, comprising within the surface to be treated a radius of a metre beyond that where the filaments are apparent, the spots are cut with the scythe. It suffices then to water the diseased spots with a 2 per cent. solution of green vitriol if the treatment be carried out in May; on the contrary, if in July a 10 per cent. solution will be required. Needless to say if one watering be not enough, the operation is repeated a few days afterwards, and watering must be copious so as to reach the matted filaments. Ponsard and Clerc advise this treatment to be done in the spring.

**Use of Green Vitriol to Combat the Diseases of Plants.**—*Chlorosis.*—In certain conditions unfavourable to the plant, chlorophyll, the active agent of assimilation, does not develop normally. A condition of languor follows, which is manifested by a yellowish or reddish coloration of all the green parts of the plant. This pathological condition is known as *jaundice*, when it is caused by a want or excess of water; *etiolation*, when it is produced by the want of light; *chlorosis*, when it is due to the want of iron. (This condition has some analogy with the anæmia of man.) But the absence of potash may induce the same phenomena. An excess of carbonate of lime in the soil,[1] insufficient nourishment, a defective condition of the roots,[2] a pathological condition of the whole plant,[3] insufficient heat, are so many causes which may produce a chlorotic condition of the plant. Hence it is easy to understand that iron cannot always remedy these diseased conditions. It can only be of real service where the chlorosis is due to a want of iron, or to an excess of lime,[4] and of minerals rich in unassimilable potash. In jaundice and etiolation it would be of no use. In the case of a tree attacked by chlorosis, the cause must above all be carefully determined and iron only used well to the purpose. Where chlorosis is due to a want of iron, the use of iron salts is to be prescribed, and they will yield always a green coloration in a short interval as well as give new vigour to the plant. The dose to use varies in different cases. There are numerous methods which are more or less effective, and which act more or less rapidly.

1. **Application of Green Vitriol to the Soil.**—The most usual method is to spread green vitriol in crystals around the tree in doses of 1—2 kilogrammes (2·2 4·4 lb.) per tree, and preferably after a heavy rain. The dose is of no great matter; an excess of green vitriol would not injure the tree, as it is converted into insoluble derivatives in the soil. Used thus its action is slow but durable. To get a more prompt effect it is better to act thus: A circular trench is dug round the tree, at a distance from the trunk, varying with its size, from 20—40 inches and a width of 8–12 inches. After well watering it, 1—2 lb. of green vitriol in crystals are sprinkled into it, or better still, a mixture

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[1] Viala has shown that a vine in pot treated with 2 kilogrammes (4·4 lb.) of lime became chlorotic in forty days.

[2] Dementjew having found different acari on the roots of trees attacked by chlorosis attributed that disease to their presence.

[3] Roux believes he observed micro-organisms in plants attacked by chlorosis.

[4] According to Dementjew's experiments an excess of carbonate of lime would only induce chlorosis when there was a lesion of the roots, a healthy root being only able to absorb a normal amount of lime; barium chloride as well as common salt produce chlorosis under like conditions; it would thus be the acari which he found on the roots which by producing lesions were the prime cause of the chlorosis of the tree.

of manure and green vitriol in powder; the soil is filled back into the trench and copiously watered. It is preferable to dig out a basin around the diseased tree and to fill in 10–20 litres (2·2—4·4 gallons) of a 10 per cent. solution of green vitriol (Tomé) or a 5 per cent. (Guirand). By repeating this treatment several times, every eight days, the cure will be rapid and complete, and the action will be more prompt as the tree is more in sap. The dose to use which in certain cases may be very weak (Sorauer advises a solution of 100 grammes of green vitriol, 30 grammes of saltpetre, and 20 grammes of phosphate of potash per tree), ought, on the other hand, to be very strong if the soil is calcareous. When carbonate of lime is the predominating cause of chlorosis, as is the case with trees with seed pips, such as the pear, and more especially the vine, the amount of green vitriol used must be greater the richer the soil is in carbonate of lime. If the normal quantities to be spread on the soil of a vineyard generally vary between 300 and 1500 kilogrammes per hectare (264—1320 lb. per acre), these quantities should rise to 4—8 metric tons (3520—7040 lb. per acre) when the soil is highly calcareous (Viala). This dose is spread in winter on the soil and buried by hoeing. Vernet recommends, so as to diminish the dose of green vitriol and to increase the action, the use of a 5 per cent. solution acidulated with 5 per cent. of sulphuric acid. At the rate of 2 litres per stock the results were perfect, and did not injure the roots. Sulphuric acid by converting the carbonate of lime into sulphate of lime lets the green vitriol penetrate more easily as far as the roots, and prevents its conversion into insoluble carbonate of iron without immediate effect on the plant. The treatment of chlorosis by vitriolizing the roots tends to disappear because it is slower than treating the aerial part of the plant with green vitriol solutions.

2. **Use of Green Vitriol on the Aerial part of the Plant.**—**(A) As Spray.**—Eusèbe Gris was the first to find that by spraying the leaves of a chlorotic tree with a 0·5 per cent. solution of green vitriol the leaves rapidly assume a green coloration, first on the spots in contact with the green vitriol, then over all their surface. This process gives much quicker results than when the iron is absorbed by the roots, but the effect is also more ephemeral, unless spraying is repeated several times a year. It then forms an excellent method against chlorosis. However, like blue vitriol, green vitriol in decomposing liberates sulphuric acid injurious to plants and thus produces corrosions and scorchings which only the simultaneous use of lime can remove. The amount of green vitriol to be used in spraying must, therefore, be well estimated so as not to exceed the amounts recognized as harmless. Two per cent. solutions burn the leaves treated. Brunet and Delacharlony found that the vine did not suffer in contact with a 2 per cent. solution, but they recommend not to use the latter except on adult leaves. In spring a 1 per cent. solution must do.

**(B) Use as a Coating.**—This process is based on the absorptive power of plant tissues in contact with solutions of metallic salts. Rassiguier tried to make a radical cure of chlorosis of the vine by introducing green vitriol in a strong dose into the sap. After preliminary pruning in autumn at the fall of the leaf whilst there is still a movement of the sap, the sections are coated with a 40 per cent. solution of green vitriol; a large portion of the iron is then absorbed. In the spring the pruning of the vine is completed. This process has given marvellous results, especially on vines growing in soils very rich in lime, and it has replaced the process which consists in spreading on the soil strong doses of green vitriol in the form of crystals. But it is recognized that poisoning occurs with 50 per cent. solutions, but not with 40 or even 30 per cent. solutions which produce the same salutary effect. Thus Guillon recommends the use of 20 or 25 per cent. solutions for young and 30 per cent. for adult vines. This method which has numerous partisans has been used with the fourfold end in view of (1) curing chlorosis; (2) combating anthracnose; (3) destroying cryptogamic germs; and (4) preserving vines from frost. But to attain this end, instead of only coating the sections the whole stock must be coated from top to bottom with a 30—40 per cent. solution of green vitriol. This treatment, which is done in this case in the autumn, retards from ten to twelve days the exit of the buds and may thus preserve the vine from late frosts. Used on the large scale in Cognac and Charente this process gives most precise and satisfactory results. André has adapted the Rassiguier treatment to fruit trees. After autumn pruning he coats the same day the sections and all the wood with a 30 per cent. solution of green vitriol. This process, very effective on young trees attacked by chlorosis, is not energetic enough for large trees, on which it is necessary to decapitate the branches and to make slight incisions in the bark of the base of these branches. By means of a brush a 30 per cent. solution of green vitriol is caused to penetrate as far as the sapwood. These coats should be applied at intervals of eight days. Favourable results were got chiefly on cherry-trees, pear-trees, and peach-trees; the yield in fruit is much increased, and amongst the latter the rust completely disappears. Green vitriol can thus be entrained by the sap without injuring the plant. Very interesting trials conducted by Mokrzecki thus confirm this fact: He pierced one or several holes in the trunk of the tree and there introduced green vitriol in crystals, then closed the holes with mastic. An average dose of 12 grammes suffices to suppress chlorosis.

(C) **Use as an Injection in the Trunk.**—The satisfactory results obtained by the extra-racinary nutrition of trees and by the injection of nutritive salts into the sapwood of the trunk induced Mokrzecki to hope to cure chlorosis by injection of solutions of green vitriol into the sap. He pierced one or more holes of 1—1·75 centimetres ($\frac{2}{5}$—$\frac{5}{7}$ inches) in diameter in the trunk and injected 12 grammes of green vitriol in 0·05—0·25 per cent. solution. So that the solution may be entrained by the sap it is of importance to prevent access of air into the hole during the time it is being pierced. To accomplish this it is necessary to proceed as follows: The point of the centre-bit is passed through a metal tube which communicates by an india-rubber pipe with the reservoir containing the green vitriol solution. By working the centre-bit the liquid forthwith fills the space drilled out and thus prevents the access of the ambient air. The reservoir is hung to a branch and the liquid thus introduced under a certain pressure. The holes are pierced through the sapwood. A tree with a diameter of 20 centimetres (8 inches) is capable of absorbing 8 litres ($1\frac{3}{4}$ gallons) in twenty-four hours. As soon as the operation is finished the hole is refilled with mastic. The most favourable time for this work is the months of March, April, or May, when the sap is in motion. Trees attacked with chlorosis show from the fourth day a greener colour in their leaves; in ten days chlorosis is no longer to be seen, and in three weeks the leaves are deep green. Trials made on 840 trees leave no doubt of the efficiency of this treatment. During his experiments Mokrzecki also observed that all the organs of these trees were influenced favourably, the buds were more vigorous, fruits more numerous, growth more rapid, and that especially if the treatment was combined with extra-racinary feeding, which finds many partisans nowadays. The same observer has pointed out that pests such as *Diaspis fallax*, Horv., of the pear-tree and *Mytilaspis pomorum*, B., of the apple-tree were much less numerous and even disappeared from the trees treated with green vitriol. It is the same as regards the *Gum* and the *Fusicladium.*

**Cryptogamic Diseases of Plants.**—Attempts have been made to combat by green vitriol and green vitriol bouillies diseases capable of being restricted by blue vitriol and cupric bouillies. Green vitriol being much cheaper than blue vitriol this substitution would have had great pecuniary advantage. Unfortunately, the dose to use being ten times larger to produce the same effect, this advantage disappeared, and the use of green vitriol was restricted to the parts of the plant which bear this treatment. Used in the same strength as blue vitriol in spraying leaves attacked by various diseases it does not produce the same salutary effect. However, its action is not *nil*, and its stimulating power on the vital functions of the plant causes the latter to suffer less from the attacks of parasites, and often prevents their spreading.

*Potato Scab.*—Nijpels found that green vitriol spread on potato fields appreciably diminished the scab of the tubers without completely preventing it.

*Bacillary Gum of the Vine* (Mal Nero).—The only remedy capable of stopping the spreading of this disease is the radical removal of all the diseased parts. The wounds produced by pruning are coated with a concentrated solution of green vitriol and afterwards covered with a mastic. Where contagion is to be feared it suffices to coat the pruned sections to prevent the disease penetrating by the wounds. Meunier practised winter coating in his domain on every stock with a 50 per cent. solution of green vitriol with 2 per cent. of sulphuric acid. The effect was very satisfactory, the parts which had previously perished were cured and contagion avoided.

*Bacterial Disease of the Mulberry.*[1]—Ruiter recommends the green vitriol treatment. As soon as a branch appears attacked it is cut off in the healthy part a few centimetres below the diseased spot. The cut branches are burned on the spot, then the pruned section is coated with a 45 per cent. solution of green vitriol. Trees so treated grow in the same year of treatment vigorous buds and next year show no trace of the disease.

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[1] MULBERRY DISEASE, BACTERIAL.—Boyer and Lamber discovered that this disease is due to the *Bacterium mori*. It shows itself on the outside by brown-black spots on the lower face of the leaves and the branches; on the latter the spots are elongated and are eroded in the form of more or less deep cankers.

*Phytophthora infestans*, de By. (potato disease).—Green vitriol exerts an energetic action on the conidia of this fungus and a 1 per cent. solution should produce an effect on the disease. Tried as substitutes for cupric bouillies, 1 per cent. solutions of green vitriol used in two sprayings, the first on 18 June, the second on 15 July, produced no improvement. Petermann obtained by this process the following results : The plot treated gave 8·3 per cent. of diseased tubers and 73 lb. of tubers. The check plot gave 11·3 per cent. of diseased tubers and 102 lb. of tubers. A strong manuring with green vitriol in the spring will give such vigour to the potato plant that it will better resist this disease.

*Peronospora viticola*, de By. (mildew of the vine).—According to Wuthrich the spores the most sensitive to green vitriol are those of *Peronospora*. A solution of 0·0139 per cent. kills the conidia after fifteen hours' immersion. The first trials to combat mildew were made in 1882. Millardet recommended a mixture of 4 lb. of green vitriol in powder, 20 lb. of green vitriol, and 20 lb. of plaster. A nursery of 2000 Jacquez attacked with mildew in the middle of June was treated 2 July in dry and hot weather. Success was complete; the young buds had not suffered, and they resisted the re-invasion of September. Reich found that the treatment for anthracnose is also a preventive of mildew. This treatment, which consists in coating the stocks with a 25—50 per cent. solution of green vitriol before the buds begin to unfold, is used with success at Armeilliere against the *Peronospora*. This treatment is not always followed by the desired effect.

*Ustilago* (smut) and *Tilletia* (bunt).—Green vitriol has no action on the spores of *Tilletia levis*. Wuthrich showed by laboratory tests that a 1·39 per cent. solution of green vitriol hinders the development of the spores of *Ustilago*, and a 13·9 per cent. solution kills them. The trials of Boiret made by sowing the spores of brown rust on object glasses placed in a moist chamber at 18—20° C. gave analogous results. A certain number of spores still germinate after an hour's immersion in a 5 per cent. solution of green vitriol or after four hours' immersion in a 2 per cent. solution, whilst the spores do not germinate in a 0·5 per cent. solution of blue vitriol. Green vitriol has, however, been used for a long time to disinfect seed corn against smut and bunt. A 2—5 per cent. solution of green vitriol was used in which the seeds were left to macerate for six to twelve hours, after which they were limed, then left to dry in the air. The results obtained were not very satisfactory. Mathieu de Dombasle artificially infected a portion of grain by agitation in a sack with the dust of brown rust, then he treated the infected grain with green vitriol, blue vitriol, and lime. After sowing he got the following results (see table, p. 194).

Although the action of green vitriol on the grains of wheat is much less injurious than that of blue vitriol, this action, ten times less cryptogamicidic than the latter salt, forms no inducement to use it as a substitute. Used ten times more concentrated than blue vitriol its pecuniary advantages disappear. Henriot made interesting trials on the pickling of seed-wheat. The seeds steeped for twenty minutes in a 1 per cent. solution of green vitriol germinated quicker and more uniformly, and produced more vigorous plants, than the unpickled seeds sown in the same conditions. Besides the plants seemed less sought after by insects than the check plants. On peas the increased yield was 100 grammes more per square metre. Turnips also gave an increased yield, and were not attacked by the fly (altises). Henriot recommends pickling cabbage seed, radish seed, turnip seed, peas, haricots, salad, etc., seeds to secure quicker germination and a bigger yield.

*Puccinia* (rust).—The uredospores do not germinate after fifteen hours' immersion in a 13·9 per cent. solution of green vitriol. The æcidiospores, more sensitive, do not germinate after immersion for the same time in a 1·39 per cent. solution (Wuthrich). Used by Galloway to combat rust of winter wheat, green vitriol was found incapable of restricting that disease, but used in 0·5 per cent. solution on young plants before its appearance, this disease was considerably lessened. Used as manure, green vitriol completely prevents this disease because it imparts more vigour to the plant. Numerous experiments have shown green vitriol to be a preventive. The doses to apply on the large scale do not exceed 2 cwt. per hectare, say 88 lb. per acre; this manure is spread on the soil in the spring the same time as the seed is sown.

TABLE XXIII.—*Showing the Results of the Experiments of de Dombasle on the Disinfection by Green Vitriol of Seed-corn Artificially Infected on Purpose.*

| | Percentage of infected ears. |
|---|---|
| 1. Check plot, grain not treated . . . . . . | 486 |
| 2. Grain sown after two hours' steeping in a 1·2 per cent. solution of green vitriol . . . . . . | 469 |
| 3. Grain sown after two hours' steeping in a 2·4 per cent. solution of green vitriol . . . . . . | 570 |
| 4. Grain moistened twenty-four hours before sowing with a 4 per cent. solution of milk of lime . . . . . | 470 |
| 5. Grain steeped for one hour in a 1·2 per cent. solution of blue vitriol . . . . . . . . . | 8 |
| 6. Grain steeped for twenty-four hours in a cupric bouillie of 10 per cent. lime and 1·4 per cent. blue vitriol . . | 2 |

*Polyporus* (polypores).—Prillieux advises to destroy *Polyporus fulvus*, Fries, which lives on fruit trees, and particularly on the olive, by the same treatment as for anthracnose. After having cut out the fungus, the bark and wood already attacked are removed, then the bared surface is moistened with a 50 per cent. solution of green vitriol, rendered more active by the addition of 2 per cent. of sulphuric acid. The wounds are afterwards protected against fresh infection by covering them with a layer of tar. Sirodot advises this operation not to be done in autumn, which is that of the fructification of the parasite, and to choose warm dry weather as much as possible.

*Exoascus deformans*, Fuckel (leaf curl of the peach).—By treating peaches with green vitriol according to Rassiguier's method, and repeating it at intervals, André caused the rust to vanish completely.

*Erysiphe communis*, Wall. (mildew of the pea).—Deneuville advises green vitriol as a preventive used thus: Sow the peas and cover them in April with a green vitriol in powder, then give the ground a slight but uniform touch with the harrow. Excellent plants which rise up well and free from blight are thus obtained.

*Nectria ditissima*, Tul. (canker of the pear, the apple, and the beech).—Prillieux recommends, to kill this fungus, and to protect wounds against its invasion, the process just described for the destruction of polypores and against anthracnose. All the parts of the wood attacked and coloured around the canker must be removed by cutting, for even apparently healthy parts may contain ramifications of the mycelium. By carefully moistening these bared parts with the corrosive solution of green vitriol and sulphuric acid, the cankers are cured.

*Dasyscypha Wilkommi*,[1] Hartig (canker of the larch).—Prillieux recommends to destroy this fungus, which belongs to the *Pezizes*, the same treatment as the *Nectria ditissima*.

*Claviceps purpurea*, Tul. (ergot of rye).—The spores of this fungus are those which resist immersion for the longest time even in concentrated solution of green vitriol. Solutions of 1—10 per cent. have no action on them. In spite of that McAlpine recommends to prevent and combat this disease a 1·4 per cent. solution. The spores do not find on the cereals strengthened by this ferruginous treatment the soil favourable to their growth, and the less number of diseased plants is due to the improvement in their power of resistance of both healthy and attacked plants.

*Dematophora necatrix*, Hartig (white root rot).—Dufour tested comparatively the action of green vitriol and blue vitriol on this fungus, and found the latter much superior to the former. However, Beniling and Behaix recommend green vitriol against rot of vine roots (Wurzelschimmel) where carbon disulphide and sodic fluoride had no action.

*Rhizoctinia violacea*, Tul. (rhizoctinia of lucerne and beet).—Buback tried to contend against this fungus by spreading 4 kilogrammes (8·8 lb.) of green vitriol on a plot of ground 10 square metres, then sowing beets eight days later after burying the green vitriol. The result was that the iron salt greatly stimulated the growth of the beets, increased the sugar, and that the plot had only 28 per cent. of diseased plants against 47 per cent. in the check plot.

*Gloeosporium ampelophagum* (grape rot).—Sulphuring and treating the vine with cupric bouillies have not circumscribed this disease at the same time as the oidium and mildew. Anthracnose must be treated by itself, and only winter treatment with green vitriol has proved entirely satisfactory. Schnorf was the first to advise and use 50 per cent. solutions of green vitriol to contend against this disease, and Skawinski was the first to add to these solutions a small amount of sulphuric acid to render the solutions more corrosive. This last formula has given perfect results. Studied in different countries, this mixture has undergone some alterations of no importance. Sorauer advises a 40 per cent. solution, Tomé a 35 per cent., Ghirardi from 0·5—2 for young shoots, so as to prevent scorching by stronger doses. Bolley advises 50 per cent. of green vitriol and 5 per cent. of sulphuric acid; Galloway 6 per cent. of green vitriol and 0·45 per cent. of sulphuric acid; Scribner 23·6 per cent. of green vitriol, 6·6 per cent. of blue vitriol, and 1·9 per cent. of sulphuric acid; Thomas 20 per cent. of green vitriol, 14 per cent. of blue vitriol, and 12 per cent. of fat lime; finally, Orillard 25 per cent. of green vitriol and 10 per cent. of blue vitriol.

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[1] DASYSCYPHA WILKOMMI (canker of the bark of the larch).—The canker of the bark of the larch often causes very great ravages. The first symptom is manifested by a yellow tint which the branches assume, the leaves fade and there is almost always a flow of [oleo] resin which is produced at a point where the bark is swollen and broken.

Contrary to the opinion of Berlèse, who attributes the success of these mixtures to their (free) sulphuric acid content, alone capable in his opinion of sterilizing the cankers produced by anthracnose, green vitriol employed pure is perfectly capable of giving excellent results; moreover, it has the advantage over 10 per cent. sulphuric acid solutions of not scorching the buds, and only retarding their unfolding slightly. If the addition of blue vitriol be not injurious, and if mixtures containing this product have given excellent results in the Haute-Garonne, this salt is not indispensable, and adds to the cost of the treatment. To-day 50 per cent. solutions of green vitriol acidulated by sulphuric acid are in constant use in Bordeaux; they are included in the annual treatment of vines in Medoc, and in all districts which suffer from anthracnose. The green vitriol solutions are made thus: 50 kilogrammes (110 lb.) of green vitriol are placed in a wooden or stoneware vat, then mixed with 1 litre of sulphuric acid of 53° Bé. Whilst stirring with a stick 100 litres (22 gallons) of hot water are run into the receiver. The precaution of first mixing the green vitriol crystals with the sulphuric acid is necessary to avoid projection of corrosive liquid. The solution is applied hot to prevent crystallization on cooling. The stock is coated with a big brush, or with a plug of rags attached to the end of a wooden handle, then all the stock, the stem, the arms, and the runners are soaked without respecting the eyes. However, it is necessary to coat from below upwards so as not to scorch the buds; it is also preferable to unbark the stock before using this corrosive liquid. The operation should always be carried out during the repose of vegetation; it is a winter treatment which is best done twice with fifteen days' interval; the last operation takes place fifteen days before the opening of the leaf, that is to say, at the moment the spores germinate. The best season is therefore the end of February or the beginning of March, but often this treatment is applied at the moment the buds begin to open. After coating the wood should become black. If rain ensue and this change has not taken place the treatment must be repeated. Green vitriol solutions in no way attack the buds, but none the less retard their opening fifteen days. The districts where anthracnose prevails suffer much from frost, and this retardation of vegetation is very beneficial to the vine. The operation should be done in calm weather so as to avoid too great evaporation of the solution. It takes 8—10 litres (1·76—2·2 gallons) of this solution for 1000 stocks of vines. Spraying may be used with great advantage, the work is done quicker than with the brush, but it involves the use of tools with glass reservoirs. When anthracnose is developed during plant growth, it is contended against by mixtures of sulphur and green vitriol in powder; this treatment stops the development of the spores, but it should be renewed several times to protect the vine; it is, in fact, a preventive rather than a curative method.

*Ophiobolus graminis*, Sacc. (disease of the stem of wheat).—This disease may be avoided by burying in the soil 80 kilogrammes of green vitriol per hectare (70·4 lb. per acre) (McAlpine).

*Dothichiza populea.*[1]—To prevent infection through wounds it is sufficient to coat them with a solution of 10 per cent. of green vitriol and to cover them with a mastic.

**Use of Green Vitriol against Insects.**—*Anthonomus pomorum* (apple blossom weevil).—Mohr advises to kill this insect in winter when it seeks refuge in the inequalities of the bark, to scrape the trunk, collect and burn the bark, and coat the whole trunk afterwards with a pasty mixture of 20 lb. of green vitriol, 10 gallons of water and a sufficiency of potters' clay. Spraying with a 20 per cent. solution of green vitriol would appear to be as efficacious as liming the trees or Balbiani's coating.

*Cochylis ambignella*, Hubn. (tortrix of the vine).—The grubs resist somewhat concentrated solutions of green vitriol. A 2—3 per cent. solution has no effect (Mohr), nor a 10 per cent. solution (Dufour). Martini diminished the *Cochylis* 27 per cent. by winter decortication followed by coating with a 45 per cent. solution of green vitriol and 1 per cent. of phosphoric acid.

*Tipula pratensis*, L. (meadow gnat).—The larvæ of the tipula, which cause ravages in meadows and lawns, are killed by green vitriol: it is, however, preferable to till the meadow, spread green vitriol, and sow again.

*Aphides.*—Naked plant lice are sensitive to the action of green vitriol. A 1 per cent. solution kills them (Mohr). On fruit trees injected with green vitriol and conveying this product in their sap, coccides such as *Diaspis fallax* and *Mytilaspis pomorum*, which live on this sap, gradually disappear. Mohr found that the larvæ of the woolly aphis *Schizoneura lanigera*, Hausmann, are killed by an emulsion of green vitriol 1 lb., amyl alcohol 5 lb., water 10 gallons. The action of green vitriol on phylloxera is *nil.*

*Botrytis.*—If pustules are noticed on gooseberry bushes in the late winter, a spraying with copper sulphate of strength 4 lb. to 100 gallons of water should be given as nearly as possible before the buds break: pustules of *Botrytis* must be completed wetted. On no account must this spray be used when the bushes are in leaf. If a severe attack of *Botrytis* occurs after the bushes have broken leaf, and only in an emergency, a spray of Bordeaux mixture, of strength 8 lb. of copper sulphate, 8 lb. of lime to 100 gallons of water, may be used. The treatment should first be given a trial on a small plot, as it is very probable that a Bordeaux spray will cause considerable leaf injury.

*Nematodes.*—Green vitriol applied in large doses as manure on infested fields kills nematodes (Zimmermann).

*Earth-worms* (Lombricus) are also destroyed by green vitriol, which can be mixed with the manure.

*Snails and Slugs.*—Slugs are very sensitive to green vitriol. To destroy them spread a mixture of green vitriol and sand in the evening, preferably in wet weather, on the soil frequented by snails and slugs. Rouzaud advises to protect vine buds from slugs by coating the stem with a solution of green vitriol, which penetrating through the mucous of the slugs kills them if they climb on a stem treated in that way.

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[1] Dothichiza populea.—This fungus penetrates into the wood of the poplar through wounds and kills the parts invaded.

**Ferric Sulphate,** $Fe_2(SO_4)_3$.—**Preparation.**—By heating 100 parts of green vitriol, 100 parts of water, and 20 parts of sulphuric acid, then adding nitric acid until no more brown fumes appear. The brown solution on evaporation yields a yellow salt.

**Properties.**—Soluble in water and endowed with the disinfectant properties of green vitriol.

**Use.**—Griffiths particularly recommends it against parasitic fungi. As a tonic he regards it as superior to green vitriol because it is more directly assimilable by the roots.

**Ferrocyanide of Potassium** (yellow prussiate).—**Preparation.**—By calcining blood in closed vessels with potassium carbonate potassium cyanide is formed and removed by lixiviating the mass with boiling water. The lye is then boiled with iron in contact with air; there is absorption of oxygen and yellow prussiate is formed. The crystallized salt is obtained by concentration and evaporation.

**Use.**—Mouillefert tried yellow prussiate on *Phylloxera vastatrix.* He watered a phylloxera-infested vine in a pot containing 3 litres of earth with a 2 per cent. solution. At that strength yellow prussiate killed all the phylloxera. Mouillefert renewed his trials on the large scale. He laid down 100 grammes ($3\frac{1}{2}$ oz.) of prussiate around each stock and afterwards applied water. The results confirmed the poisonous action of this substance. Unfortunately, it is not without effect on the plants and it temporarily injures the vine. Knop formerly showed that if yellow prussiate was capable of imparting to the plant the iron which it required, it was, on the other hand, often injurious to it. He made the curious observation that the prussiate added in small dose to no matter what nutritive liquid stopped growth forthwith of the plants in no matter what stage of growth. Without dying the plant appeared to stop growth; it subsisted but showed no growth. It follows from the experiments of Bahadur (?) that yellow prussiate is a very feeble poison to young plants and absolutely harmless to fungi when used in the dark. It is quite otherwise in the light. It decomposes with formation of prussic acid which renders it poisonous.

# CHAPTER XI

## POTASSIUM BICHROMATE (BICHROME)—CHROME ALUM—POTASSIUM PERMANGANATE—NICKEL SULPHATE—COBALT SULPHATE

**Potassium Bichromate,** $K_2Cr_2O_7$. Chrome Alum, $K_2SO_4Cr_2(SO_4)_3$, $24H_2O$.—**Preparation.**—Bichromate of potash is obtained commercially by calcining chrome ore on the sole of a reverberatory furnace with half its weight of nitrate of potash. The mass is then lixiviated with water and acetic acid added to saturation. Whilst precipitating silica and alumina this acid converts the neutral chromate into bichromate. After filtration the liquor yields, when concentrated, orange crystals of bichromate of potash. Chrome alum is obtained by treating a solution of 150 lb. of "bichrome" with 250 lb. of sulphuric acid and 60 lb. of alcohol.

**Properties.**—Crystals of "bichrome" are permanent in the air. They dissolve in ten times their weight of water at 29° C. Chromates are very poisonous; in small doses they produce, by a specific slow poisoning, caries of the bones of the nose.

**Action of Chrome Salts on Plants.**—Chrome salts, chiefly chromates, are poisonous to plants. H. Coupin in 1898 determined the toxicity of the different chrome salts by adding them to a nutritive solution; he found that the following quantities disturbed the growth of cereals :—

TABLE XXIV.—*Showing the Toxic Dose of Different Chrome Salts in a Nutritive Solution* (Coupin).

| | Per cent. |
|---|---|
| Chrome alum | 1·142 |
| Chromium sulphate | 0·5 |
| Chromic acid | 0·00595 |
| Potassium chromate | 0·0625 |
| Bichromate of potash | 0·03125 |
| Sodium chromate | 0·0125 |
| Bichromate of soda | 0·0064 |
| Ammonium chromate | 0·0625 |
| Bichromate of ammonium | 0·025 |

**Action of Chromium Salts on Parasitic Fungi.**—It follows from Hitchcock and Carleton's experiments that whilst a 1 per cent. solution of chrome alum has no action on the uredospores of the *Puccinia coronata*, Corda, a 1 per cent. solution of bichromate of potash lowers considerably the germinating capacity of these spores after twenty-four hours' immersion and destroys them by more prolonged contact. A 0·1 per cent. solution has no action on the uredospores, but if the contact be prolonged after nineteen hours the germination of the spores becomes more difficult.

**Permanganate of Potash,** $KMnO_4$.—**Preparation.**—By heating in an iron crucible a mixture of 50 parts of manganese dioxide with 50 parts of potassium chlorate and 60 parts of potash dissolved in the smallest quantity of water. This mixture is gradually heated to dull redness, then cooled and extracted with boiling water. A purple liquid is thus obtained which crystallizes on evaporation in blackish violet needles with metallic lustre.

**Properties.**—Potassium permanganate dissolves in 15—16 parts of cold water. It is a powerful oxidizing agent decomposing organic matter in the cold. Owing to this property it acts as an energetic and rapid disinfectant; its sterilising action is instantaneous, especially in the presence of an acid. Weak permanganate solutions do not keep in open vessels, and it is best to use these anticryptogamic solutions immediately after their preparation.

**Action on Fungi.**—The spores of fungi resist the action of this oxidizing agent better than that of poisonous salts. Hitchcock and Carleton found that the uredospores of the *Puccinia graminis*, Pers. (linear rust) can germinate in a 1 per cent. solution of permanganate of potash. Arieti found that the dose required for the disinfection of seed-corn was so strong that it killed the grain as well as the adherent spores. It is otherwise with the mycelium of fungi. The tender filaments of the mycelium are easily destroyed by permanganate solutions; the effect is produced instantaneously. But as permanganate solutions cannot penetrate into the organs of plants to destroy the mycelium which vegetates in and between the cells, permanganate finds no application except to destroy fungi, the mycelium of which live on the surface of the plant, that is to say *Erysiphe* and *Capnodium*.

**Action on Insects.**—The action of permanganate is weak and sometimes *nil*. Perroncito immersed the eggs of *Bombyx mori*, L. (silkworm) in a 1 per cent. solution. After twelve hours the action was *nil* ; only after twenty-four hours' immersion were the greater part of the eggs destroyed. Trials made in 1872 (Samal process) to destroy the phylloxera of the vine by watering the stocks with a 0·06 per cent. solution failed because the permanganate was decomposed before reaching the roots infested with this aphis. However, Stengele recommends a 1·25 per cent. solution of permanganate to kill infallibly the woolly aphis.

**Use.**—*Erysiphe communis*, Wal. (mildew of the pea).—Douaire simultaneously tried sulphur and permanganate of potash against this parasitic fungi, the mycelium of which lives on the surface of the diseased plant, and he obtained the best result with the latter. Used at the rate of 1 lb. in 100 gallons of water permanganate completely stopped the invasion of this fungus. A few days after this treatment the less-attacked leaves had become green again, whilst those which were greatly attacked bore black spots in the places where the epidermic cells had suffered from the fungus. To obtain a definite result spraying must be done carefully so that both surfaces of the leaves are moistened. This treatment only produces a curative effect, never a preventive one. It can in no way prevent a fresh invasion by spores coming from elsewhere.

*Oidium Tuckeri*, Berk. (oidium of the vine).—Of all the fungi the mycelium of which live on the exterior of the diseased plant the most formidable is the oidium of the vine, which, if very resistant to copper salts, may be easily contended against by sulphur and soluble sulphides. Permanganate of potash has also been recommended to kill this parasite. Guocdenovic tried a 0·1 per cent. solution of permanganate which proved entirely satisfactory. Kulisch repeated these experiments to compare the results with sulphur. He used solutions made at the rate of 1¼—2½ lb. per 100 gallons of water. He found permanganate produced good results, but the good effect was purely local, and to obtain a complete result it was necessary to reach the whole surface of the plant by spraying. On the other hand, sulphur, which acts by the vapours which it disengages and which penetrate everywhere, produces complete disinfection without it being necessary to cover the whole surface of the vine with sulphur. It has been seen that it is sufficient when the temperature and the atmospheric conditions are favourable to deposit the sulphur at the foot of the stocks to destroy the oidium completely. The advantage of permanganate of potash lies in the fact that it can be mixed with cupric bouillies without losing its properties. Added to Bordeaux bouillie one can contend in a single treatment against oidium, mildew, and black rot, which is a great economy of time.

*Peronospora viticola*, de By. (mildew of the vine).—Ch. Truchot recommends a permanganate solution of 0·125 per cent. against mildew. Tried in the Canton of Vaud in Switzerland it sometimes gave excellent, sometimes negative results. It is otherwise with a mixture of Bordeaux bouillie and permanganate of potash. Guocdenovic made up bouillies containing 0·75 per cent., 0·5 per cent., 0·25 per cent. of blue vitriol and 0·1 per cent. of permanganate of potash. Compared against ordinary Bordeaux bouillie these permanganate bouillies gave better results even when they only contained 0·25 per cent. of blue vitriol and 0·1 per cent. of permanganate of potash. This mixture whilst giving excellent results effects great saving in copper. The permanganated Bordeaux bouillie behaves both like Bordeaux bouillie and as blue vitriol, that is to say, it possesses, along with the reserve of copper to prevent the invasion of the mildew and prolong the action of the bouillie remaining on the leaves, a very active substance having an immediate deadly action on the exterior organs of these fungi, the conidiophores. This bouillie gives good results when it is a case of arresting a sudden invasion during a moist warm period of summer. However, permanganate alone does not suffice to contend against this disease, for it has only a curative action and is entirely deprived of preservative effect. It is therefore necessary to multiply the treatments an infinite number of times with permanganate alone to get a result analogous to that obtained with cupric bouillies or permanganated cupric bouillies.

**Disinfection of Trees.**—It has been recommended to coat fruit trees in the spring when the buds are barely formed with an 0·125 per cent. solution; it is even recommended to spray the whole trees with this solution after flowering. The results were very satisfactory.

*Botrytis Douglasii*, V. Tub. (conifer disease).—The rot of conifers produced by *Botrytis cinerea*, Pers., has been combated by Van Biervliet by making sprayings with a bouillie consisting of—

| | |
|---|---|
| Copper sulphate | 700 oz. |
| Carbonate of copper | 1360 ,, |
| Permanganate of potash | 85 ,, |
| Soft soap | 225 ,, |
| Rain water | 500 gallons. |

*Nematodes.*—Humphrey got excellent laboratory results against the nematodes of the violet by frequently spraying with a 0·05 per cent. solution. The experiments on the large scale, however, did not succeed.

**Nickel Sulphate,** $NiSO_4,7H_2O$.—**Preparation.**—Nickel sulphate is formed by dissolving nickel, its hydrated oxide or its carbonate, in dilute sulphuric acid of 15° Bé. It crystallises from its solutions in the hydrated state with 7 molecules of water.

**Properties.**—Crystallized nickel sulphate is green; it dissolves readily in water. Alkalies yield with solutions of nickel sulphate an apple-green precipitate of hydrated oxide of nickel insoluble in water, soluble in ammonia and in carbonate of ammonia. The ammoniacal solution of protoxide of nickel dissolves silk (Schlossberger). There is thus great analogy between the physical and chemical properties of nickel and copper sulphates as between nickel hydrate and copper hydrate. A nickel hydrate bouillie behaves as to solubility in atmospheric agents and its adherence like Bordeaux bouillie.

**Action of Nickel Sulphate on Plants.**—Nickel sulphate, like copper sulphate and other poisonous plants, possesses the property of stimulating the vitality of these plants if absorbed by them in minimum proportion. Richards treated different fungi and algæ growing in nutritive solutions with small quantities of nickel, copper, zinc, and cobalt sulphates, sodium fluoride, lithium nitrate, sodium arseniate. The dose required to stimulate algæ is much less than for fungi. By increasing the dose there is an immediate poisonous action on plants; 2½ milligrammes of nickelous oxide used as nickel sulphate in 1 litre of water (2½ parts in 1,000,000) stop the growth of maize and haricot. Nickel sulphate behaves like blue vitriol in a nutritive solution used to combat the cryptogamic diseases of plants; it, owing to the infinitesimal quantities absorbed by plants, imparts more vigour, and that in itself gives more resistance to the plant. However, the stimulating effect of nickel sulphate is not so decided as that of copper salts.

**Action of Nickel Sulphate on Parasitic Fungi.**—Nickel sulphate has a very toxic action on parasitic fungi. It much resembles that of blue vitriol, to which it is superior or inferior according to the parasite treated. A 1 per cent. solution of nickel sulphate does not kill the uredospores of *Puccinia coronata*, Cord.

**Use.**—*Peronospora viticola*, de By. (mildew of the vine).—Galloway tried nickel sulphate and nickel hydrate against blue vitriol and cupric bouillie. He concluded that its sporacidic and preservative action is inferior to that of cupric derivatives. Sbrozzi's trials confirmed this conclusion. Guocdenovic made comparative experiments with 0·25, 0·5, 0·75 per cent. copper bouillies and with nickel hydrate bouillies, made like Bordeaux bouillie with 0·25, 0·5, and 1 per cent. of nickel sulphate. The action of these bouillies was identical. The 0·25 per cent. nickel hydrate bouillie was still active, and more effective than the Bordeaux bouillie with 0·25 per cent. of blue vitriol. He concluded that nickel bouillie could perfectly well replace Bordeaux bouillie against this fungi.

*Botrytis cinerea*, Pers. (grey rot of the vine).—Viala and Gouirand made interesting researches on the comparative action of nickel and copper sulphates on this redoubtable fungus. According to the experiments copper salts have little action on the germination of the *Botrytis*. Whilst the spores of *Peronospora viticola* are killed in a solution of 3 parts in 10,000,000 of blue vitriol, it takes a 5 per cent. dose of blue vitriol to prevent the germination of *Botrytis cinerea*. It is not so with nickel sulphate, which is 40 times stronger than blue vitriol. In a solution of two parts per 10,000 the spores are almost entirely prevented from germinating. Nickel carbonate has shown the same superiority as compared against the Burgundy bouillie, for whilst it takes a 7·5 per cent. cupric bouillie to prevent all spores from germinating in sixteen hours, a 1 per cent. nickel bouillie has the same effect. The results, repeatedly verified, have always been the same. Experiments on the large scale against grey rot do not appear to have been made as a sequel to the laboratory experiments of Viala and Gouirand. Is it because aluminium sulphate, much cheaper, produces equally good results ?

## CHAPTER XII

### RED LEAD LEAD ARSENATE—LEAD ACETATE (SUGAR OF LEAD)—SILVER NITRATE (LUNAR CAUSTIC)

**Red Lead,** $Pb_3O_4$.—**Preparation.**—By heating massicot or litharge, PbO, in special furnaces to 450—500° C.

**Properties.**—Red lead is a brilliant red powder, insoluble in water.

**Use.**—Seed beds may be completely preserved against the attacks of sparrows and other granivorous birds as follows: 20 lb. of seed are mixed with 1 lb. of red lead and stirred, so that the seeds may be uniformly red. The seed is sown as usual and the birds shun the land where they have been sown. Von Tubeuf recommends red lead particularly to preserve pine and spruce fir seeds.

**Arsenate of Lead,** $Pb_3As_2O_8$.—**Preparation.**—By acting on a solution of 10 lb. of arsenate of soda with 18 lb. of lead acetate, or 15 lb. of lead nitrate, dissolved in water. To prepare the bouillie the liquor is made up with water to 250—376 gallons. Marlatt's bouillie contains 10—24 lb. of arsenate of lead and 50 lb. of glycose in 1000 gallons of water.

Some new American processes for the manufacture of lead arsenate are electrolytic. By another method colloidal lead oxide is made in a colloid mill and arsenic acid added, the temperature being maintained at 80—100° C., until combination takes place, which is completed in a few minutes.

**Properties.**—Lead arsenate is one of the most insoluble of arsenates in water. It forms in the bouillie a finely divided precipitate which remains well in suspension, which is not the case with many of the arsenite greens of a density of 3 and the consistency of which is very granular.

**Action on Plants.**—Owing to its insolubility it is perfectly harmless to the plant, and that is one of the great advantages of this product, for all arsenates are more or less soluble in water, and thus more or less injurious to plants. Woods' experiments on potatoes have shown the harmlessness of three sprayings annually and spreading 5·5 lb. of arsenate of lead altogether (? per hectare, say 4·4 lb. per acre). Besides, it was impossible to find even traces of arsenic in the tubers. A bouillie containing 0·5—1·0 per cent. of arsenate of lead never scorches the leaves, so that bouillies containing a large proportion of poison may be used, when the insects stand strong doses of arsenic and resist all arsenite of copper bouillies.

**Action on Insects.**—Its poisonous action on insects is not in equal doses as rapid as that of copper arsenite. Arsenate of lead is a violent poison for man. Used without precaution it is as dangerous as lead salts and arsenites. It chiefly affects the sight. Some cases have been quoted in America where this bouillie is in constant use.

**Use.**—Lead-arsenate bouillie cannot replace copper-arsenite and lime-arsenite bouillies in every case. Its greater adherence, increased by the addition of glucose, is such that it remains fixed on the organs of the sprayed plants during the whole season. This adherence, therefore, excludes it in all cases where the plants or the fruits treated are intended for food. But, wherever that is not the case, lead arsenite may replace copper arsenite. The bouillies are best made on the spot; 0·2 per cent. suffices in most cases. But some parasites require 0·7 per cent., and even 1 per cent. It is calculated that it takes three to four times more of this bouillie to obtain the same result as from that with an emerald-green basis. But the lead-arsenate bouillie, consisting of a flaky precipitate, enables the poison to be more uniformly distributed, and by its white colour shows the spots touched. One preparation of arsenate of lead contains lead oxide 49, arsenic acid 16, tar 4, water 31 = 100. Lead arsenate is especially used against a butterfly whose caterpillar has become quite a plague—

*Ocneria dispar*, Sch., or *Liparis dispar*, L. (*Bombyx dispar*,[1] gypsy moth).—Spraying with cupro-arsenical bouillies is without effect as the caterpillars are capable of absorbing strong doses of copper arsenite without dying. By the use of a 1 per cent. lead arsenate bouillie very satisfactory results have been got in America. To destroy the caterpillars the spraying must be done at the time they are hatched, for the young caterpillars are more sensitive than the adults. It is possible to destroy 90 per cent. of the young caterpillars and only 60—70 per cent. of the adults. This process, therefore, appears to give better results than the gathering of the nests of eggs in winter. Flour mixed with dry lead arsenate, so as to produce a 3 per cent. gluten mixture, has been successfully used in gypsy moth spraying machines.

Tent caterpillar (*M. pluvialis*).—U.S. Laboratory experiments to determine the toxic values and killing efficiency of the arsenates gave results as follows: Lead hydrogen [acid lead] arsenate has a higher killing efficiency at a given dilution than either calcium or basic lead arsenate. It requires a longer period of time to kill the nearly mature caterpillars than the small forms. All of the arsenic devoured by the insects in feeding upon sprayed foliage is not assimilated, but a portion passes through the intestinal tract in the excrement. The percentage amount of the arsenic assimilated depends upon the arsenate used; lead hydrogen arsenate was assimilated readily and most of the arsenic was retained in the tissues while much of the basic lead arsenate was found in the excrement. It requires approximately 0·1595 milligramme of arsenic pentoxide to kill 1,000 small tent caterpillars, and approximately 1·84 milligrammes of arsenic pentoxide to kill 1,000 nearly mature tent caterpillars, irrespective of the particular arsenate used as a spray.

*Leptinotarsa decemlineata* (Colorado beetle).—Woods recommends to destroy insects injurious to potatoes, such as the Colorado beetle, altises, etc., a bouillie consisting of 0·24 per cent. of lead arsenate. If it be desired to combat cryptogamic parasites simultaneously there is added to Bordeaux bouillie 24 lb. of arsenate of lead per 1000 gallons. Lead-arsenate bouillie is in general use in America. The following is, however, a list of the insects against which it has been particularly recommended: (1) *Galeruca luteola*, Sch., on the elm; (2) *Galeruca anthomelæna*, Schr., on the elm; (3) *Crioceris asparagi*, L., asparagus beetle; (4) *Rhopobota Vacciniana*, Pack., butterfly injurious to the cowberry (whortleberry, Kirkland); (5) *Orthocraspeda trima*, Moore, butterfly injurious to the cacao tree (Zehntner); (6) *Plutella, Margantia, Mamestra*, aphides, insects injurious to cabbages (Garman); (7) *Ennomos subsignaria*, phalena of the apple (Garman); (8) *Carpocapsa pomonella*, codlin moth. Trials to destroy this moth were made with a Bordeaux bouillie containing 6—12 lb. of lead arsenate or of disparin per 1000 gallons. Gillete and Garman by its use reduced the percentage of wormy apples from 50 per cent. (on the check trees) to 4 per cent. Experiments made on a large scale in the U.S.A., where infestation by *Cydia* (*Carpocapsa*) *pomonella*, L., normally affects 100 per cent. of unsprayed fruit, indicate that the factors underlying control of this pest by arsenical treatments are the amount of arsenic applied per tree per treatment, the constancy with which the coating is maintained during the periods of entry, and the concentration of the moth, either through the agency of prevailing winds or through other natural increase. Concentration is the most powerful of these factors, and it is believed that this can be overcome through the cumulative effect of the employment of arsenicals. With regard to the amount of arsenical per tree, it was found that for apple trees 18 to 20 ft. high and 25 to 30 ft. across, $\frac{2}{5}$ lb. lead arsenate in 10 U.S. gallons spray per treatment per tree gave excellent results. Larger amounts might be an advantage, but do not seem to be so. The importance of maintaining the coating thus given during the period of entry by larvæ of the first and second generation is not generally realised, because in cases of comparatively light infestation a single heavy coating may be adequate to check the entering larvæ of either the first or second generation. (9) *Emphroctis chrysorrhea*.—Weed advises to cut the nests in the spring and spray with lead arsenate on the young caterpillars; (10) *Grapholitha botrana* (tinea of the vine).—Slingerland recommends three sprayings with a 1 per cent. bouillie of lead arsenate, the first a little before flowering, the second after flowering, and the third when the grapes are the size of a pea.

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[1] BOMBYX DISPAR, LIPARIS DISPAR, OCNERIA DISPAR (gipsy moth).—Great difference between the two sexes—the male has greyish-brown wings 3 centimetres, the female has yellowish-white wings 5 centimetres; the two are marked by zigzag lines. The female lays 500 eggs and covers them with a felt formed from the long brown hairs of its abdomen, the whole resembling a small sponge. In the United States they form a real plague.

*Pieris rapæ*, L.—In Ontario, dusting experiments prove that lead arsenate dust gives the best results, calcium arsenate in liquid form being very unsatisfactory as well as scorching the foliage. Against *Polychrosis viteana* (grape berry moth) in Michigan the spray recommended is $1\frac{1}{2}$ lb. lead arsenate to a barrel of Bordeaux, with 1 lb. resin fish-oil soap as an adherent. Each acre requires 300 U.S. gallons, applied under pressure, shot upward from below by the trailer method —that is, by a man following the spray apparatus with an extension and a nozzle set at right-angles to the extension.

*Prionoxystus Macmurtrei*, Guér. (lesser oak carpenter worm) is one of the most destructive pests of red oak (*Quercus rubra*) in Canada. To kill it, lead arsenate (4 or 5 lb. to 1 U.S. gallon of kerosene emulsion and 50 U.S. gallons of water) was used, as sodium arsenate injured the foliage severely. To combat the elm leaf beetle (*Galerucella luteola*, Müll.) in Michigan, the trees are sprayed with 3 lb. of lead arsenate to 100 U.S. gallons of water when the beetles appear on the new growth in the spring and again when the larvæ begin work in July.

Remedial measures employed in the U.S.A. against *Epitrix parvula*, F. (tobacco flea-beetle) are as follows: Locate the plant beds as far as practicable from the flea-beetle hibernating quarters. Sow the seed early, bank the earth about the boundary poles, and use sound cheese cloth properly applied. Poison the bed if flea-beetles appear, using the one-in-six mixture (1 lb. of Paris green, with 5 lb. of lead arsenate) at the rate of ½ lb. per 100 sq. yards. Before pulling the plants, dust at the rate of 1 lb. of the mixture to 100 sq. yards of plant bed. If a liquid spray is preferred, use from 1½ to 2 lb. of the mixture in 50 U.S. gallons of water. For newly-set plants use about 3 lb. per acre of the one-in-six mixture in all methods of application, except the stick-can (a tin fastened to a stick and having nail holes in the bottom through which the dust is sifted on to the individual plants). With the stick-can the formula should be 1 lb. of Paris green in from 20 to 40 lb. of flour, about 5 lb. of this mixture being applied per acre. For field control on tobacco, half grown or larger, use from 4 to 6 lb. per acre of the one-in-six mixture.

The Brown Vegetable Weevil, *Listroderes* (*Desiantha*) *nociva*.—Australian experiments show that 1 lb. of lead arsenate powder in 50 gallons of water kills 78 per cent. of the weevils in 2 days, while dusts of lead arsenate and calcium arsenate kill 83 and 87 per cent. respectively. Potatoes are not injured by the undiluted powder; but for more delicate plants it might be diluted to 1 part to 10 parts of hydrated lime. For small plants, the tops of food-plants may be dipped in a lead or calcium arsenate solution, or dusted with diluted powder after dipping in water, and placed between the rows of infested plants. This should be done towards evening, so that the treated tops are fresh and attractive when the beetles are feeding.

A mixture of ½ lb. of lead arsenate paste with 10 gallons of water is recommended by the British Ministry of Agriculture for use against the pear and cherry sawfly and caterpillars of the Magpie moth. Work up the paste with a little water, then add the remainder. A spray of 1 gallon of lime-sulphur to 29 gallons of water and 4 lb. of arsenate paste to the 100 gallons of spray fluid gave very good results against apple scab (*Venturia inæqualis*) in experiments carried out by the British Ministry of Agriculture. It is recommended against moths and caterpillars and other leaf-eating pests. It is applied as a fine spray. Lead arsenate is a deadly poison and should not be used on fruit that is to be gathered green, or where vegetables are grown under the trees.

In the Niagara Peninsula the grape-berry moth [*Polychrosis viteana*, Clem.] is controlled by spraying with 1½ lb. lead arsenate, 1 lb. soap and 40 gallons Bordeaux mixture. In the case of the grape-vine flea-beetle [*Haltica chalybea*, Ill.] 2 lb. lead arsenate, ½ gallon cheap molasses and 40 gallons water, applied as soon as the beetles appear in numbers, will largely prevent injury to the buds.

Cabbages in the western parts of North Carolina are considerably damaged by the larvæ of Lepidoptera, the worst pests being *Phytometra* (*Autographa*) *brassicæ*, Riley (cabbage looper) and *Pieris* (*pontia*) *rapæ*, L. (imported cabbage worm). The remedy recommended, as a result of tests lasting from 1917 to 1920, is the application of 1 lb. of dry powdered lead arsenate to 6 lb. of dry powdered air-slaked lime. The time and manner of application of this dust are discussed. The efficacy of lead arsenate against *Neurotoma* (*Lyda*) *nemoralis* on apricots has been proved; in a normal season, arsenical treatment should be given at the end of April or beginning of May, to leave as long a period as possible before gathering the crop. Equally good results can be obtained with contact insecticides of 2 per cent. soft soap solution with the addition of 1 per cent. of titrated nicotine or concentrated tobacco extract; or with 1 part of pyrethrum-soap to six parts of water; these should be applied somewhat later, as soon as all the larvæ have hatched. Heavy applications of spray, using 3 to 5 lb. of lead arsenate in 50 U.S. gallons of water has given as much as 95 per cent. mortality against *Rhynchites bicolor*, F. (rose curculio), in Manitoba.

The most serious pest of loquats [*Eriobotrya japonica*] in certain localities of Bermuda is a small brown caterpillar, which attacks the flowers and developing fruit. Spraying with ½ oz. lead arsenate powder to 1 gallon water has been recommended; the addition of ½ lb. sugar per gallon will assist in preventing fruit-fly injury.

Chemical studies of the combined lead arsenate and lime-sulphur spray in the U.S.A. show that when acid lead arsenate (which is more efficient as an insecticide than basic lead arsenate) is mixed with lime-sulphur solution, a definite chemical change takes place whereby the weight of insoluble solid matter in the mixture is nearly doubled. Chemical changes can be prevented by adding hydrated lime, but the solid residue in the spray mixture is thereby correspondingly increased. The undesirable reaction does not take place if preparations containing casein (which also acts as a spreader) are used in small proportions. Skim-milk, with added lime, or commercial calcium caseinate preparations may be used for this purpose. The indications are that there is little likelihood of reduction in efficacy of the sprays combined in this way, while the danger of scorching seems to be reduced to a minimum. The addition of tobacco dust to combined lead arsenate and lime-sulphur sprays also prevents undesirable reaction in the compounds, without the addition of casein or lime.

**Lead Acetate,** $Pb(C_2H_3O_2)_3,3H_2O$.—**Preparation.**—By dissolving lead oxide in acetic acid.

**Properties.**—Soluble in water, with a saccharine taste. Very posionous, like all lead salts, and absorbed in small regular doses it causes the complaint known as painters' colic.

**Action on Plants.**—Placed in strong doses in contact with the roots of plants it kills them, yet young plants of peas, maize, and oats, cultivated in nutritive solutions, are not killed in four days after receiving 1 per cent. of lead as lead nitrate. By slow absorption in small doses it eventually produces a paralysis of growth, an arrest of the normal growth.

**Action of Lead Acetate on Parasitic Fungi.**—Hitchcock and Carleton found that the germinative power of the uredospores of *Puccinia* *coronata*, Corda, was reduced by immersion in a 1 per cent. solution of lead acetate.

**Use.**—*Peronospora viticola*, de By. (mildew of the vine).—Kaserer made a series of experiments against this disease, spraying with the following bouillies :—

| | | | | | | |
|---|---|---|---|---|---|---|
| Mixture of | 100 | grammes | of lead | acetate | and | milk of lime. |
| ,, | 250 | ,, | ,, | ,, | ,, | ,, |
| ,, | 500 | ,, | ,, | ,, | ,, | ,, |
| ,, | 500 | ,, | ,, | nitrate | ,, | ,, |

The lead hydrate which is formed by lead acetate or nitrate with milk of lime appears to have, owing to its solubility in pure water, a rather decided action on the spores of *Peronospora viticola*. Owing to the rapid conversion of lead hydrate into insoluble carbonate of lead, the action of the bouillie is not so lasting as that of copper bouillies. Besides the adherence of the deposit is less than that of Bordeaux bouillie. The vines treated showed no signs of poisoning.

# CHAPTER XIII

## COPPER SULPHIDE—COPPER NITRATE—COPPER CHLORIDE—COPPER SULPHATE (BLUE VITRIOL)

**Copper Sulphide,** $CuS$.—**Preparation.**—(1) By passing a current of sulphuretted hydrogen into a solution of a copper salt. The black precipitate formed is filtered and washed with a solution of sulphuretted hydrogen. (2) By double decomposition of sulphate of copper by the sulphide of an alkali or alkaline earth.

**Properties.**—Copper sulphide is an amorphous black precipitate, absolutely insoluble in water. In moist air it oxidizes and forms sulphite and sulphate of copper. By heat it decomposes into basic copper sulphide and sulphur.

**Use.**—Copper sulphide has been recommended against oidium as well as mildew, that is to say, to unite in a simple treatment both sulphur and Bordeaux bouillie. Copper sulphide, containing the necessary elements to fight these two parasites, it was thought might produce the desired effect. It was not so, however, and Viala's experiments showed that copper sulphide neither protects vines from mildew nor kills the oidium. Numerous observers hold the same opinion as Viala and condemn mixtures which form copper sulphide. In fact, the copper is so insoluble in this sulphide derivative that this preparation no longer cedes to dew or rain the indispensable amount of copper to prevent the germination of the spores which have been transported by the wind, and the sulphur in the sulphide no longer possesses the properties of sulphur. It is not volatile, and cannot consequently act by its vapours. However, copper sulphide may oxidize in the air and thus cede to the water on the leaves a little soluble copper as copper sulphate. This, in fact, occurs in moist countries, and it is one of the reasons why certain experimenters found a protection in it against mildew equal to that of bouillies. The special bouillies recommended by Fairchild, and afterwards by Rabatè, may perfectly combat oidium, but they have only an imperfect action against mildew. Consisting of a mixture of 4 lb. of copper sulphate and of 4 lb. of sodium polysulphide (liver of sulphur) in 100 gallons of water, in the first instance, and a mixture of copper sulphate and lime sulphide in the second, they contain, along with precipitated copper sulphide, sulphides, or polysulphides of sodium or calcium, as well as precipitated sulphur, which have a well-determined action on oidium.

Against *Entomosporium maculatum* (spots of the leaves of the pear) Fairchild did not find his bouillie superior to ordinary copper bouillies. Galloway, however, found it act better against rust of oats and summer wheat. Plots treated on 6, 16, and 20 June, then on 5 July, were not diseased, and yielded 10½ units of sound grain against 8½ units in the untreated plots, the plants of which were diseased.

If sulphur be mixed with fat lime in the proportion of fat lime 260 lb., precipitated sulphur 260 lb., water 7 gallons, and the product mixed with a copper salt in the following proportion, above mixture 4 lb., copper sulphate 2 lb., water 10 gallons (Guillon's formula), a bouillie is obtained which, used immediately after its preparation, enables oidium and peronospora to be contended against simultaneously, because sulphur only acts véry slowly on copper hydrate to form copper sulphide. It is otherwise if a solution of copper sulphate is mixed with soluble sulphides, or even if the sulphur is added to alkaline bouillie; these bouillies are blackened instantly by the copper sulphide formed and are now merely copper sulphide bouillies, less adherent and less active than Bordeaux bouillie.

**Copper Nitrate,** $Cu(NO_3)_2,3H_2O$.—**Preparation.**—By dissolving copper in dilute nitric acid and crystallizing the solution.

**Properties.**—Soluble in water with the same anticryptogamic properties as copper sulphate.

**Use.**—Hitchcock and Carleton tried the effect of a 1 per cent. solution on the spores of different fungi. At that strength the spores of rust (*Puccinia coronata*) were destroyed. Copper nitrate is regarded as one of the best means of destroying weeds, and is used on the large scale to destroy charlock.

**Copper Chloride,** $CuCl_2,2H_2O$.—**Preparation.**—By dissolving copper carbonate in hydrochloric acid, or copper in aqua regia, and evaporating the solutions. Copper chloride bouillies are prepared by mixing 249 lb. of copper sulphate and 219 lb. of calcium chloride; sulphate of lime is precipitated and copper chloride goes into solution.

**Properties.**—Copper chloride is soluble in water. It behaves like copper sulphate as regards its corrosive action on leaves and its anticryptogamic effects. Its molecular weight being 170, that of copper sulphate 249, and the action of copper salts being in inverse ratio to their molecular weight, the chloride will, in doses of equal weight, be more active, and should be used in smaller doses than copper sulphate. Galloway has, however, remarked that dilute solutions of copper chloride do not attack the leaves of plants like those of copper sulphate; it is necessary to attribute this difference to the different nature of the hydrochloric acid and sulphuric acid which form these two salts; the first is volatile, the second is not so.

Galloway used against the black rot of the vine a mixture, consisting of $7\frac{1}{2}$ oz. of copper sulphate, 4 oz. of calcium chloride, in $62\frac{1}{2}$ gallons of water. This bouillie much diminished the black rot. The vines sprayed six times showed 98·1 per cent. of healthy grapes against 41·61 on the untreated stocks. On the other hand, being very dilute it does not attack the leaves at all. A 1 per cent. solution prevents the germination of the uredospores of *Puccinia coronata*, Corda (rust of oats). Along with pure solutions of copper chloride there are used in America, with little success it is true, solutions containing oxychloride of copper obtained by precipitating copper sulphate with bleaching powder. These bouillies, studied by Fairchild, consist of blue vitriol 2 lb., chloride of lime 3 lb., in 100 gallons of water, or of blue vitriol 2 lb., chloride of lime 4 lb., in 100 gallons of water. These bouillies, which, like true Brunswick green, $CuCl_2,3CuO,4H_2O$, contain a greater or less excess of chloride of lime, produce very disastrous effects on the leaves. Compared with other bouillies they are less adherent and less active against cryptogamic diseases. Tried against *Entomosporium maculatum*, Lev. (spots of the leaves of the pear) they do not prevent the disease, and seriously damage the leaves.

**Sulphate of Copper,** $CuSO_4,5H_2O$ (blue vitriol, blue copperas).—**Preparation.**—By roasting mineral sulphides of copper in reverberatory furnaces and in a highly oxidizing current of air. The mass obtained is lixiviated with hot water and the blue liquor crystallized.

**Properties.**—Blue vitriol prepared thus is often impure.[1] It is thus less active as an anticryptogamic. That used to combat plant diseases is prepared by oxidizing copper turnings in a reverberatory furnace and dissolving the product formed in sulphuric acid. Crystals of copper sulphate are dark blue, transparent, with a styptic taste. They effloresce slightly in the air because above 15° C. they lose a part of, and at 100° C. the whole of their water of crystallization. One hundred lb. of water dissolve 36 lb. (10 gallons) of blue vitriol at 19° C., 88 lb. at 50° C., and 213 lb. at 104° C. In medicine its emetic properties are utilized in doses of 25—30 centigrammes. In croup it is administered even to children in doses of 1—2 centigrammes every ten minutes until the false membranes are expelled. Blue vitriol is, moreover, a powerful disinfectant, used especially to disinfect linen soiled in cholera cases, typhus, and other epidemic diseases. Blue vitriol is not poisonous to man to the same extent as lead, mercury, arsenic, antimony, and phosphorus. It acts as a caustic on the mucous membranes, and may produce, when it is absorbed in abundance by the stomach, a gastro-intestinal catarrh, which is rarely fatal. Given in certain regular doses it may interfere with the functions of the nervous and muscular systems and produce cachexy, but that disappears rapidly with the cause.

Blue vitriol coagulates albumen; it is thus hæmostatic like ferric salts, but copper albuminates are soluble in alkalis, acids, alkaline chlorides, and even in an excess of albumen. This property explains the comparative harmlessness of copper salts which are regularly eliminated by the kidneys. Absorbed by the stomach only a small portion of it enters the blood. The stomach eventually tolerates very strong doses. At the Salpetrière up to 125 grammes of ammoniacal sulphate of copper were given to epileptic patients in 165 days. Blue vitriol in doses of 25—60 grammes (383—920 grains) is generally fatal, but cures are known after absorption of 125 grammes (1918 grains). Such large doses are, moreover, difficult to swallow, the stomach soon rejecting poisonous doses. Copper salts are more poisonous the greater their solubility; the oxides, as well as metallic copper, have in fact little action on our organism. Contrary to an ancient prejudice, toxicologists admit to-day, with just reason, that copper salts are but slightly poisonous. Dr. Galippe has shown that 50 centigrammes to

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[1] It in fact often contains green vitriol and zinc sulphate. If it be desired to detect these the blue vitriol is dissolved in water, and carbonate of soda or milk of lime added. Pure blue vitriol gives a sky-blue precipitate, if it contains green vitriol it gives a dirty-blue precipitate, if it contains zinc sulphate the precipitate is of a pale bluish colour. [Peroxidize the solution with nitric acid, add large excess of ammonia or caustic potash (KHO), filter, a brown residue = iron.—Tr.]

1 gramme of copper salts may be swallowed daily without fatal accidents. Workers in copper, those who work in verdigris factories, show no signs of poisoning even if, owing to the daily absorption of copper, their hair, nails, and skin turn green, a colour which, according to Petri, is produced by the deposit of microscopic salts of copper. The copper daily absorbed would rather, according to Dr. Pecholier, have a beneficial effect on the organism, an effect analogous to that which is produced by iron salts. He has remarked that chlorosis never exists in workmen engaged in verdigris factories, and that workmen, anæmic when they entered, were quickly cured of that complaint. The fear expressed formerly that the treatment of vines by copper salts might introduce into the wine poisonous substances injurious to the consumers is not, therefore, justified. The doses borne by the human organism are much greater than those which could be absorbed in articles of diet containing copper. Different fruits treated with copper have been absorbed without inconvenience (Fairchild). Moreover, 1 kilogramme of grapes, which came from a vine treated with Bordeaux bouillie in autumn, only contained 17—35 milligrammes of copper, whilst preserved green peas contain 11—125 milligrammes; the amount found in the wine is still less. According to analyses the maximum of copper found in wines, from vineyards treated with copper bouillie, was from 2·5 milligrammes per litre in red wines to 1 milligramme in white wines; in the greater number of wines the average amount of copper does not reach one-hundredth of a milligramme. This amount of copper contained in wines, comparatively small in comparison with that which enters into the vat, arises from the fact that the copper remains insoluble in the lees. To prove it, it suffices to place a handful of blue vitriol in the vat; the copper will remain in the lees and not pass into the wine. The tables prepared by Crolas, Raulin, as well as by Millardet, show this fact decisively.

TABLE XXV.—*Showing the Distribution of Insecticidal and Anticryptogamic Copper between Wine Lees, etc.*

| | Copper in lb. per 100,000 gallons or 1,000,000 lb. of wine. | | | |
|---|---|---|---|---|
| | Wine. | Picquette. | Marc. | Lees. |
| 1 lb. blue vitriol in 40 gallons water . . . . . . | 0·23 | 0·00 | 11·0 | 49 |
| 1 lb. blue vitriol, 1 lb. ammonia in 40 gallons of water, eau celeste | 0·25 | 0·14 | 12·8 | 81 |
| 6 lb. blue vitriol, 15 lb. lime in 10 gallons water, Bordeaux bouillie . . . . . | 0·00 | 0·1 | 10·4 | 92 |

The different parts of the vine treated by a copper bouillie contain the following amounts of copper in milligrammes per kilogramme: leaves 24·9—95·5; stem and wood, 5·8; grapes, 15·9—18·6; marc, 11·1—29·9; wort, 1·0—2·2; wine, 0·1. The amount of copper entrained into the wine is so small that it does not even interfere with the fermentation. The development of the ferments is not hindered up to 0·3 gramme of blue vitriol per litre, a dose, therefore, which can never occur in wine. It must, therefore, be admitted, that before the action of copper can make itself felt, a man must absorb several hundred litres of wine a day.

**Action of Blue Vitriol on Plants.**—To ascertain the action of a soluble salt on a plant the latter is grown in an artificial medium containing a known dose of the salt to be examined. Haselhoff found that the greater number of plants suffered in such conditions from a small dose of blue vitriol. According to him the dose of 0·001 per cent. is injurious in almost all cases, but the deadly action of blue vitriol already shows itself in presence of 0·0005 per cent. with certain plants, and even with 0·00011 per cent. (Devaux). Normal growth is impossible, except in presence of much weaker doses of blue vitriol. Thus peas grow normally in a 0·00005—0·000001 per cent. solution. Maize grows in a 0·000005 –0·0000001 per cent. solution. Grain only stands very weak doses of sulphate of copper; the young plant is killed by 0·004875 per cent. of copper bromide, 0·005 per cent. of copper chloride, 0·00555 per cent. of copper sulphate, 0·005714 per cent. of acetate of copper, 0·0061 per cent. of copper nitrate. It follows from these experiments that copper salts are violent poisons to plants when the roots are in presence of their solutions. Coupin's table proves that copper salts do not act through their acids, as Monselice asserts, but by their copper. The following are the successive phases through which a plant, placed in a medium containing a poisonous dose of blue vitriol, passes: If a branch of cryptomeria, of Pinus or of Thuya, is dipped in a 0·01—0·05 per cent. solution of sulphate of copper, the chlorophyll contracts and ruptures and the interior of the cell browns. If young plants be placed therein the roots at first turn white, then become yellow and brown, grow up abnormally, then die. By analysing the different organs of a plant killed by a solution of blue vitriol, Devaux found traces of copper in all its parts. R. Otto, who submitted some plants (*Phaseolus vulgaris*, *Triticum vulgare*, *Zea Mays*, *Pisum sativum*) to the action of blue vitriol in a nutritive solution, found, on the other hand, that these, in spite of the deformation of their roots and their diseased state, only contained a very little copper in the roots and none at all in the aerial parts. Hence he concluded that blue vitriol is so poisonous to the plant that as soon as it has penetrated into the cells of the root it there occasions such disturbances that the plant dies before it can be conveyed further.

This conclusion may be a sound one when the plant is placed in contact with large quantities of a copper soluble salt, because in such conditions the living cell is opposed to the osmosis of the salt. Nageli also believes that blue vitriol kills the cell as soon as it is absorbed by it, but that the latter does not suffer so long as it can prevent its penetration. Nageli's experiments on a green, fresh-water alga, *Spirogyra*, which possesses, like phanerogams, chlorophyll and plasma, showed that a solution of blue vitriol of 1 part in 100,000,000 sufficed to cause the death of this alga. The effects produced on the chlorophyll and the plasma are very visible under the microscope. The conditions which we create artificially in a culture liquid do not exist, however, on the large scale, and it would be rash to conclude by analogy that blue vitriol acted in the same way on plants grown in the open field. If the soil be watered with a solution of blue vitriol, chemical reactions are produced between this salt and the soil which convert this soluble salt into one or more insoluble compounds, and copper salts being more poisonous the greater their solubility, insoluble salts such as oxide of copper have no action on the plant. It is not necessary to go far to find an analogous example. Mercury as bichloride, a soluble salt, poisons man even in very small quantity. It no longer has any injurious action when it is absorbed as calomel, an insoluble product. These two salts, however, possess the same elements, chlorine and mercury, but their different action on the organism lies in the fact that corrosive sublimate, being soluble, coagulates albumen, whilst the insoluble calomel passes through the organism without causing any trouble. Similarly the plant shows signs of poisoning in presence of blue vitriol, because the latter is soluble and capable of producing copper albuminates, but it remains indifferent to the presence of insoluble copper compounds on the large scale. When solutions of blue vitriol are spread round a plant this salt all falls into the soil, and the roots are no longer in contact with a poisonous and corrosive liquid but in presence of an insoluble compound. The plant will absorb the homœopathic quantities which are beneficial to it, dissolving them by means of the acid juices of its roots, by its chemical and physiological exertions. The soil is capable of absorbing enormous quantities of blue vitriol without the latter injuring the plant (the soil naturally contains copper; Vedrosi found in arable land 0·01—0·15 per cent. of copper oxide, the average amount is from 0·06—0·08 per cent.). Viala watered vines in pots regularly for three months with a solution of blue vitriol and mixed in this soil the dose of 200 grammes of this salt without the vine perishing. Girard cultivated rye, oats, clover, and potatoes on a soil treated with $1\frac{1}{2}$ metric tons of blue vitriol per hectare (1320 lb. per acre). Taft concludes from his experiments that the soil does not refuse to grow plants until it contains 1 per cent. of copper. To prove that copper sulphate incorporated in a soil is no longer soluble, Gorup-Besanez watered 240 cubic centimetres of soil with a 0·1 per cent. solution of blue vitriol. This soil, washed at once with 500 cubic centimetres of water, gave up no trace of copper to the water. Similarly, Nobbe, who watered 152 grammes of dried soil with 150 grammes of blue vitriol was unable to recover with 2 litres of water only 7·1 per cent. of the blue vitriol used. In practice it has been found that the watering of plants even with comparatively strong solutions of blue vitriol is far from being injurious. On the contrary, it is salutary. In the French Sudan a trial plot sprayed with 20 lb. of copper sulphate, 15 lb. of lime, $\frac{1}{2}$ lb. of casein, and $1\frac{1}{5}$ pints of pure nicotine per 100 gallons, using 165 gallons per acre, yielded 1,554 lb. of raw cotton compared with 735 to 1,457 lb. on similar untreated plots. Rumm and Pichi found that vines watered with 5 per cent. solutions of blue vitriol, when the sap begins to circulate, resist mildew and show a certain immunity to cryptogamic diseases. But the amount of copper must not be too small; $5\frac{1}{2}$ gallons per stock of a 1 per cent. solution do not prevent mildew from attacking the vine. But complete immunity is obtained with 5½ gallons of a 5 per cent. solution. Besides this immunizing action blue vitriol possesses a stimulating power on all the vital functions of the plant, like green vitriol; plants become vigorous, their leaves more fleshy, of a deeper green, and the vitality of the plant is prolonged. Hence it may be concluded that the vine is capable of absorbing copper by the roots if that is possible.

As far back as 1819 John experimented on the absorption of copper by the roots. By mixing carbonate of copper with the sterilized sand used for his cultures he could not find the presence of an abnormal quantity of copper in the ash of the experimental plants. But when these plants were watered with very small quantities of nitrate of copper, the copper absorbed by the roots was ponderable. Peas cultivated in this medium contained in their ash sufficient copper to give a red precipitate with yellow prussiate. The ash of barley, cultivated in the same condition, contained it in such large amount that it could be precipitated and estimated by iron. Buchholz and Meissner also found that roots could absorb copper under a form which it has not yet been possible to define. Tschirch has shown that the potato absorbs the copper applied to the soil, even though the latter is watered with 4 kilogrammes (8·8 lb.) of blue vitriol in solution per 2 cubic metres of earth. The amount of copper absorbed is the greater the larger the proportion of copper applied. These results also confirm the fact that copper is present in all plants, as it is recovered in their ash. Potatoes contain 0·0028 gramme per kilogramme[1] (Deschamps), haricots 0·002—0·011 gramme per kilogramme (Galippe), chicory, salad, spinach, and clover also contain it, likewise the vine, the fig, and the plum (Papasogli). A certain amount is found in beet (Langlois), in pepper (Meissner), and in tobacco (Wicke). Vedrosi found 0·06 per cent. of copper oxide in oak wood, 0·02 per cent. in the leaves, 0·04 per cent. in the glands; in haricots the proportion is greater, and reaches 0·38 per cent.; in rye 0·19 per cent.; in wheat 0·21 per cent.; in barley 0·12 per cent.; in oats 0·35 per cent.; in maize 0·39 per cent. Whence comes this copper if it were not absorbed by the roots? This belief has been disputed by many physiologists, who, for one reason or another, have not found in plants treated with copper sulphate a ponderable amount of copper, or who have found that blue vitriol was too poisonous to be entrained through the plant like nutritive salts. Pichi, on the other hand, claims to have identified, under the microscope, crystals of copper in the mesophyll of the leaves of plants watered by blue vitriol, and Devaux's experiments prove that copper, in an insoluble form, put in contact with the roots or the leaves, is assimilated by them in infinitesimal quantities and carried through the plant under the form of an organic compound, capable of forming deposits in the cellular membranes. The difference of opinion arises in the analytical processes which have been adopted for the detection and estimation of copper in the sap or in the ash of plants. It is wrong to try to determine in all cases the amount of copper by chemical or physical methods, because they are not sensitive enough.

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[1] = oz. per 1000 oz.

The amount of copper is often so minute that it escapes detection by the chemist. Dehérain advises recourse to the extreme sensitiveness of the alga spirogyra, which is affected by the dose of 0·000001 per cent. of blue vitriol. Ewert found a more sure method, based on the presence of diastase, that is to say, on the stoppage produced in the conversion of starch in presence of diastase, by infinitesimal doses of blue vitriol, a method by which 0·00000051 milligramme of blue vitriol may be detected. If plants are visibly healthy after watering with copper salts, that results from the absorption of very small quantities of copper that can only be determined by these latter methods of analysis. It suffices to consider the infinitesimal doses of inorganic salts required to exert a stimulating effect on the human organism to understand the rôle which copper plays in the plant.

The question then appears in quite another light, and it is in homœopathic doses that soluble copper salts must be given to plants, unless reserves of copper be formed round the roots of plants and on the aerial organs with strong doses of insoluble or very slightly soluble compounds. Wuthrich was the first to point out the analogy which exists between the action of green vitriol and that of blue vitriol, and that of corrosive sublimate on the spores of fungi. The physiological effect produced on plants is likewise the same, since these three compounds are capable of coagulating albumen and other nitrogenous substances with which the life of the plant is intimately linked. The intensity of their toxic action is in inverse proportion to their atomic weight; but keeping to these proportions blue vitriol is ten times more energetic than green vitriol, and mercuric bichloride 100 times more active than the last. The same holds good as regards the stimulating effect, that is to say, that to increase the assimilation in a plant it requires 100 times less mercury and ten times less copper than of iron. These salts are, moreover, not the only ones capable in small doses of stimulating the vital functions of the plant. M. N. Ono found that poisonous salts, such as zinc sulphate, cobalt sulphate, sodium fluoride, and nickel sulphate, had in small doses lost their poisonous properties and become stimulants. Raulin found the same with salts of zinc and of silicium.

In practice it has been found that blue vitriol may render the same service as green vitriol, but that for this purpose it must be used in much smaller quantity. The analogy between the action of these two salts is so striking that it has been seriously a question of attributing this action to the green vitriol, very often present in commercial blue vitriol; some have even gone so far as to advise the addition of a little green vitriol to blue vitriol to increase its stimulating action. A manifest error was thus committed, which will be dealt with when the action of Bordeaux bouillie on the plant is considered. By watering the aerial plant the same results were obtained as by watering the roots, that is to say, the vital functions of the plant were stimulated. But if large surfaces be placed in this way in contact with a soluble salt of copper, the poisonous effects are felt more, and leaf scald results from the too large quantities of salt absorbed. If it be evident that the sulphuric acid of the blue vitriol, when liberated by certain reactions, may exercise its well-known corrosive action on the organs touched, the poisonous action of blue vitriol is especially due to the copper which, absorbed by the leaves as sulphate of copper, kills the cells of the organs traversed. These drawbacks still occur, even with 0·1 per cent. solutions. Owing to this annoying effect sprayings with blue vitriol have been abandoned, and given place to copper bouillies. The latter, which contain copper in an insoluble form, copper hydrate, or carbonate, produce on the leaves an insoluble deposit, of which the latter can absorb the amount beneficial to them. Thus there are realized on the leaves the conditions created around the roots by spraying with blue vitriol. From the foregoing it follows that blue vitriol is a violent poison to plants, and that its contact, always injurious to the plant, should be avoided. Neither blue vitriol, nor any of the other neutral salts of copper, is the suitable copper compound to be applied to plants. The pollen of flowers being very sensitive to the action of copper salts even when insoluble, forbids their application during the flowering of the plant. Miani found pollen to have the same sensitiveness as fungi spores, but that an infinitesimal amount of copper salts stimulated their vitality.

**Action of Blue Vitriol on Algæ and Saprophytic Fungi.**—Saprophytic fungi and algæ behave to blue vitriol like phanerogamous plants; stimulating in small doses blue vitriol is poisonous in large doses. It is to be remarked that blue vitriol shares this stimulating action on algæ with many other poisonous salts. Raulin remarked that zinc and silicium salts increased the vitality of the fungus *Aspergillus niger*. Other investigators made the same observation on zinc, nickel, and cobalt salts, used on the fungus *Aspergillus niger* and *Penicillium glaucum*, and on the algæ *Protococcus*, *Chroococcus*, *Stigeoclonium*, and *Hormidium*. The vitality of fungi and algæ is, to sum up, stimulated by the sulphates of zinc, nickel, cobalt, iron, and copper, mercuric chloride, sodium fluoride, lithium nitrate, potassium arsenate. The right dose for algæ is smaller than for fungi. For blue vitriol the maximum dose is 0·012 per cent.; for mercuric chloride 0·0013 per cent. Ferments (leavens) behave in the same way as fungi. According to Kruger the alcoholic fermentation of wort by *Saccharomyces ellipsoides* is favoured by doses of blue vitriol smaller than 0·01856 per cent. Pichi and Rommier found that a solution containing 0·015 per cent. of blue vitriol began to impede fermentation and that 0·03 per cent. reduced it perceptibly. Besides, copper salts are precipitated by fermentation, the ferments can thus find in the lees the amount of copper favourable to their development. There are, however, exceptions amongst plants. Thus the fresh-water algæ *Spirogyra* die in a solution containing only 0·000001 per cent. of blue vitriol, whilst other algæ resist solutions of 0·012 per cent. perfectly. *Penicillium glaucum* would even be capable of growing in a concentrated solution of green vitriol. This fact, remarked by Trabut, was examined by De Seyes. In a nutritive solution blue vitriol does not disturb the growth of *Penicillium glaucum* (Trab.) in a 9·5 per cent. dose. This fact must, however, be considered in another light to understand it. It is, in fact, recognized that *Penicillium glaucum* can grow in a poisonous medium without feeding on its elements, but by using the medium solely as a support. Hence this mould is perfectly capable of growing on a crystal of nitrate of silver, or in a solution of 1 per cent. of corrosive sublimate. Whilst germinating spores of *Penicillium glaucum* in a 9·5 per cent. solution of blue vitriol, De Seyes observed that growth did not occur except on the edge of the vessel, where the water of condensation was accumulated. Saccardo stopped all growth of this fungi in a medium containing 5 per cent. of blue vitriol by agitating the solution; whilst at rest growth was so normal that it formed *Conidiæ*. *Penicillium* therefore does not possess a special immunity for copper salts, as had been imagined, but behaves like other fungi, and R. Otto gives the dose of 0·008 per cent. as favouring its development. This dose is hardly greater than that required by *Aspergillus niger*, 0·004 per cent.

**Action of Blue Vitriol on Parasitic Fungi.**—Benedikt Prevost discovered the poisonous action of blue vitriol on parasitic fungi. In his experiments to determine the action of boiling water on spores, he made the sensible remark that water boiled in a copper vessel alone had the power to prevent spores from germinating. He then determined that it sufficed for the water to contain 1 part in 400,000 of its weight of blue vitriol to prevent the spores of rust from germinating. Kuhn examined the comparative action of blue vitriol and green vitriol, alum and sulphuric acid on the spores of rust, an examination which still throws light on the remarkable properties of blue vitriol. In 1885 Millardet found the limit of toxicity of blue and green vitriol on the zoospores of mildew, and found that these could still germinate in a solution of 1 part of lime to 10,000 parts of water, of 1 part of green vitriol to 100,000 parts of water, and 1 part of blue vitriol to 10,000,000 parts of water. In 1889 Dufour examined the action of blue vitriol on the spores of *Fusicladium pirinum*, *Claviceps purpurea*, *Pleospora*, *Phragmidium*, and other fungi, and found that the germination was normal in a solution of 1 in 1,000,000, reduced 1 in 100,000, rare 1 in 10,000. In 1891 Wuthrich tried, comparatively, potassium nitrate, sodium carbonate, zinc sulphate, zinc chloride, copper sulphate, and mercuric chloride on the spores of *Peronospora*, *Phytophthora*, *Ustilago*, *Puccinia*, and *Claviceps*, and made very instructive conclusions. Tried on the spores of the most diverse fungi, blue vitriol has been recognized as possessing a highly extensive poisonous capacity and capable of combating the greater number of the cryptogamic diseases of plants. Wuthrich was the first who described the action of blue vitriol on spores. He determined the similarity in the action of different salts, and particularly in that of blue and green vitriols. It has already been pointed out that their action on spores appears to be inversely proportional to their chemical equivalent, but that blue vitriol, regard being had to these proportions, was ten times more energetic than green vitriol. Wuthrich found that these two salts penetrated into the spores, and that death only supervened after this penetration, whilst blue vitriol could be detected in the cell by yellow prussiate, even in the case where a spore had only undergone a slight alteration in its vitality in contact with this salt. It is not the same with copper, which cannot be detected chemically in the same condition. Spores that have been steeped in a solution of blue vitriol of 0·0001 equivalent per litre, a dose which appreciably affects the vitality of the spores, absorbs so little copper that its presence in the cell cannot be demonstrated by a chemical reagent. The solution in the bath itself, moreover, gives no perceptible tint with prussiate. It is different when the spore dies as the effect of steeping in the solution of 0·001 equivalent per litre; in these conditions the dose of copper is sufficient to give a coloration with prussiate. Wuthrich concludes, therefore, that a certain dose of blue vitriol may be absorbed by the spores without killing them, but that this dose does not exceed a certain limit. The table below shows how the spores of different fungi behave after being steeped in a dilute solution of blue vitriol.

Hecke, examining the action of blue vitriol on the spores of *Ustilago Crameri* found that 0·125—1 per cent. of blue vitriol did not kill the spores, even those which had manifestly absorbed copper. A subsequent washing of the spores with water in no way changed the effect of the treatment, as is the case with spores treated with formol, but washing with 0·5 per cent. HCl reimparted to them all their vitality.

TABLE XXVI.—*Showing the Effect of Solutions of Blue Vitriol of Various Strengths on the Germination of Spores of Fungi.*

| Spores of | Germination normal per cent. of solution. | Germination abnormal per cent. of solution. | Germination nil per cent. of solution. |
|---|---|---|---|
| *Phytophthora infestans* | 0·000125 | 0·00125 | 0·0125 |
| *Peronospora viticola* | 0·000125 | 0·00125 | 0·0125 |
| *Ustilago carbo* | 0·000125 | 0·0125 | 0·125 |
| *Puccinia graminis* | 0·000125 | 0·0125 | 0·125 |
| *Claviceps purpurea* | 0·000125 | — | 0·0125 |

In 0·125 per cent. solutions of blue vitriol the copper disappears in five minutes' immersion, and is fixed on the spores. Spores of different species of smuts behave differently from this point of view.

*Ustilago Panici-miliacei.*—0·5 Gramme of spores absorbs all the copper from 5 cubic centimetres of a solution of 0·125 per cent. of blue vitriol. 0·5 Gramme of spores absorbs all the copper from 10 cubic centimetres of a 0·125 per cent. solution of blue vitriol. 0·5 Gramme of spores absorbs almost all the copper from 15 cubic centimetres of a 0·125 per cent. solution of blue vitriol.

*Ustilago Crameri.*—0·5 Gramme of spores absorbs all the copper from 5 cubic centimetres of a 0·125 per cent. solution of blue vitriol. 0·5 Gramme of spores absorbs almost all the copper from 10 c.c. of a solution of 0·125 per cent. of blue vitriol. In the filtered liquid only sulphuric acid (dilute) remains. The spores treated by 0·5 per cent. hydrochloric acid cede the whole of their copper to this acid and recover their original vitality. Blue vitriol acts, therefore, like formol, by fixing itself on the chitinous membrane of the spores of fungi and preventing their growth; treated by an acid this compound disappears, and the vital functions resume their natural course as before treatment with blue vitriol. It is not therefore surprising that blue vitriol cannot be detected in the interior of the cells by chemical reagents, since in small dose it does not penetrate but is retained on their surface. Although blue vitriol in small doses does not kill spores it prevents their normal evolution, and the object sought is found. The plant is safe. The dose of blue vitriol, therefore, required to prevent the growth of spores is very small, and it is not difficult to produce this effect, since by spraying with copper bouillies the plant is covered by a layer of a slightly soluble copper compound.

**Action of Blue Vitriol on Insects.**—The larvæ of insects with a wet skin are as sensitive to blue vitriol as snails. The adult insects may be poisoned by absorption from the leaves sprayed with copper compounds. The eggs of insects are much more insensitive to copper salts than is generally believed, and to destroy them they require steeping for a very long time in a strong solution of blue vitriol. Perroncito has shown that the eggs of silk-worm (*Bombyx mori*) easily resist a twenty-four hours' immersion in a bath of 1—2 per cent. of blue vitriol. In the same way caterpillars are not inconvenienced by contact with blue vitriol solutions. Dufour found that a 10 per cent. solution did not incommode the caterpillar of the *Cochylis* of the vine. Mouillefert immersed vine roots bearing numerous phylloxera for three days in a saturated solution of blue vitriol and still found many living insects; it was only after five days' immersion that all the phylloxera died. The great resistance of this pest is, therefore, the cause of the bad results obtained with the different processes of destruction recommended in 1872 and submitted to the control of a special commission. If blue vitriol cannot be regarded as a poison by contact, it, however, becomes poisonous when absorbed by the leaves, and the favourable results obtained by the Bordeaux bouillie admit of no doubt in the matter. Besides, insects avoid gnawing the organs touched with blue vitriol, and are thus removed by spraying. T. Tozzetti, having steeped potatoes in a solution of blue vitriol, found that the larvæ of the *Elaterides* did not touch them. In this way Angelo met with complete success against the phylloxera in the island of Elba, by injecting blue vitriol into the diseased stocks. Dying vines revived by this treatment, for the phylloxera disappeared from the stocks treated. *Anarsiœ lineatella* In France copper sulphate sprays, with the addition of 1½ lb. of pure nicotine or 10 lb. commercial triplumbic arsenate per 100 gallons of spray, have given great success when applied from the time the buds open. One treatment was found to be sufficient.

**Use of Blue Vitriol to Kill Weeds.**—Amongst chemical weed killers blue vitriol is one of the most efficient. Bonnet, a vine-grower, found it out fortuitously. He observed that the mustard which grew amongst the vines was destroyed by blue vitriol, whilst oats, growing in the same condition, were immune. Trials made by Benard and Brandin showed that a 5—10 per cent. solution of blue vitriol disorganized the cruciferæ growing amongst cereals without injuring the latter. Its disorganizing action is more powerful than that of green vitriol. Whilst it requires 15—20 per cent. of this latter salt, 4—5 per cent. of blue vitriol suffices to produce the same effect, at the rate of 44—88 gallons per acre. It is better to use mixtures of blue vitriol and nitrate of soda as weed killers. The young plants are destroyed by a mixture of 2 per cent. of blue vitriol and 10 per cent. of nitrate of soda, sprayed at the rate of 8—10 hectolitres per hectare (70·4—88 gallons per acre.

The British Ministry of Agriculture recommends that copper sulphate sold for use in a spraying mixture shall contain not less than 98 per cent. of crystallized sulphate of copper, $CuSO_4,5H_2O$. Spraying crops with sulphate of copper has been found exceedingly useful in destroying weeds. Persicaria and spurrey may be killed by spraying with 4 (16 lb. in 40 gallons) and 5 (20 lb. in 40 gallons) per cent. solutions of copper sulphate respectively; while the following weeds are more or less crippled and seeding largely prevented by spraying with a 5 per cent. solution of copper sulphate, or a 15 per cent. solution of sulphate of iron:—poppy, corn cockle, black bindweed, dock, groundsel, dandelion, perennial sow thistle, cornflower, whitlow pepperwort, thistles and coltsfoot. Against charlock better results may be got by dressing an acre with 16 lb. of copper sulphate dissolved in 60 gallons of water—thus making a 2⅔ per cent. solution. The following sprays are all fairly effective as weed killers in destroying the leaves and stems of hoary pepperwort (*Lepidium draba*, L.) if used when the plants are in flower:—(1) 40 lb. of copper sulphate in 80 gallons of water. (2) 14 lb. of copper sulphate and 56 lb. of sulphate of ammonia in 70 gallons of water.

**Use to Destroy Parasitic Plants.**—*Cuscuta minor*, DC. (small dodder of the lucerne and clover); *Cuscuta densiflora*, Willm. (dodder of flax); *Cuscuta major*, DC. (large dodder of the hop and hemp plant).—Blue vitriol kills dodder in much smaller doses than green vitriol. From 2—5 per cent. solutions of blue vitriol suffice. Their method of use is the same as for green vitriol.

*Orobanche ramosa* (branchy orobanche of hemp and tobacco); *Orobanche minor*[1] (clover orobanche).—Gennadius advises to destroy these parasites by a 5 per cent. solution of blue vitriol, which destroys their seeds.

**Use against Mosses and Lichens.**—Coating with a mixture of 6 per cent. of blue vitriol and 2 per cent. of sulphuric acid readily destroys the mosses and lichens which grow on the trunks of trees.

**Use against Cryptogamic Diseases of Plants.**—*Phytophthora infestans*, de By. (potato disease).—The analogy between the *Phytophthora* and the *Peronospora*, combated with so much success by copper salts, led to the belief of an analogous efficiency of these in preventing the potato disease. However, numerous experiments with this end in view gave less decisive and less concordant results than with mildew of the vine, but there is now no doubt that the methods used to prevent mildew of the vine are equally efficacious to avoid the *Phytophthora*. Petermann, after three treatments, only obtained 35·960 kilogrammes of potatoes instead of 46·370 on an untreated plot amongst which there were only 2·5 per cent. of diseased potatoes against 11·3 per cent. in the check plot. Montanari found that there were as many diseased tubers in the fields, sprayed with 0·25, 0·5, and 1 per cent. solutions of blue vitriol, as in those untreated. These results show that the method of application has a great influence. Frank and Kruger have shown, on the contrary, that a general preventive and judicial treatment of the potato increases its assimilative capacity, which is manifested by an over-production of potatoes rich in starch, but that it is necessary to choose other compounds than blue vitriol to obtain this end, the scorchings occasioned by sprayings of blue vitriol, to which the potato is more sensitive than the vine, being often the cause of smaller crops of tubers.

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[1] OROBANCHE MINOR (orobanche of clover, broom rape).—The orobanches are parasitic phanerogams of the roots. They live exclusively at the expense of the plant on which they graft themselves for they are deprived of chlorophyll. The seeds only germinate in contact with the roots of the nurse plants. They plant themselves there, and their root which is a mere sucker penetrates, whilst it ramifies as far as the vascular bundles. These root suckers are perennial if the orobanche is fixed on a perennial plant, and the multiplication of this parasitic plant may take place without the intervention of its seed. This is especially the case with the orobanche of clover.

To produce this favourable result it must not be forgotten that the infection of the potato may be produced either by conidia, brought on to the leaves by the wind, or by previous infection of the tubers. To be complete, therefore, the treatment ought to be double. (1) Disinfection of the seed tubers, four to five weeks before planting, so as to prevent the propagation of the disease by the tubers. (2) Repeated preventive spraying with copper preparations against the aerial invasion. The cupric treatment which can prevent the rapid progress of the disease, and its extension, in potato fields, by annihilating the conidia produced during summer, can in no way destroy the mycelium which lives in the interior of the leaves and the stems, nor prevent the progress of the disease on the infested tubers. The treatments must therefore be preventive and capable of killing the conidia or the zoospores which fall on the leaves, so as constantly to oppose the invasion of the plant by this disease. By observing all these necessary conditions the cupric treatments are crowned with the same success as the preventive treatment for mildew of the vine. This point will be dealt with more fully in describing the treatment of *Phytophthora* by Bordeaux bouillie. This latter, used judiciously, is so superior to blue vitriol that the latter has been abandoned. Sorauer recommends "cupric-sulphosteatite," a mixture of 10 per cent. of blue vitriol and 90 per cent. of talc, to combat the disease of the tomato. This preparation is added to the manure and sprayed at intervals of four to five days, and after transplanting every eight to ten days. Care must be taken not to use too much, for it may scorch the plant. Used against the potato disease, sulphosteatite has given results varying from one species to another. Whilst Liebscher declares that its use lowered the crop 31 per cent. and Steglich found it without action, Schoyen, Hollrung, and Strebel obtained in many cases superior yields up to 26·3 per cent. All are, however, agreed that its results are not so regular as those obtained with neutral Bordeaux bouillie.

*Peronospora viticola*, de By. (mildew of the vine).—Owing to its purely aerial propagation the mildew of the vine is much easier to destroy than the *Phytophthora*. It suffices to prevent the disease to stop the zoospores from germinating by poisoning them. There can be no question of destroying the mycelium in the tissue of the leaves, and if the disease has invaded the plant the treatment must be confined to preventing the propagation of the disease to neighbouring plants by the conidia coming from the plant attacked. Cupric preparations, by depositing on the leaves an adherent and slightly soluble layer, creates an insurmountable barrier to the spores of this fungi. As 2—3 ten-millionths of this salt soluble in the dew suffice to prevent the zoospores from germinating, it will be seen that the layer of the cupric compound lying on the leaves will always cede this amount to the water deposited on the leaves. The most active and efficient preparations are, therefore, those which possess a very weak solubility with perfect adherence. Blue vitriol is the copper salt which realizes these conditions to the least extent; it has therefore been replaced by the bouillies which give much better results and never injure the vine. When it was seen in Burgundy and Maconnais vineyards, ravaged by the *Peronospora*, that certain stocks preserved a normal appearance, it was found that those which were exempt from the disease were attached to new props, impregnated with blue vitriol to preserve them. This observation was communicated to the Academy of Science by Perry, who observed it himself in the department of Saône et Loire.

Experiments were made by Paulin, using vitriolized props throughout a whole vineyard, and by Prosper de Lafite, by simply steeping the ropes of straw or willow bands in a bath of blue vitriol. But these experiments were soon followed by a bolder and more rational treatment, consisting of spraying with more or less dilute solutions of blue vitriol on the foliage of the vine. These treatments, which enabled the invasion of mildew to be victoriously contended against, were, however, far from giving entire satisfaction. The proportions of blue vitriol used in the beginning were from 1—15 per cent. Muntz recommended the treatment of this disease by 10 per cent. solutions of blue vitriol. But there followed scorchings of the leaves; it is true they were not serious, but all the same alarming. The doses were reduced, owing to these mishaps, to 3 per cent., then to 1 per cent., and then by Bouchard and Beaumé to 0·3 per cent. With this dose Ricaud got the same preservative result as with the larger doses. In spite of this small dose of blue vitriol the vines showed the same characteristic burning, especially when the spraying was done in hot, warm weather, because the drops of this dilute solution deposited on the leaves concentrated rapidly, and then acted like a concentrated solution. Blue vitriol, used against vine diseases, possesses two defects: (1) injuring the foliage, (2) possessing no adherence on the leaf; rain removed all the blue vitriol deposited thereon. To obtain with these solutions the same effect as with bouillies, it would be unceasingly necessary to multiply the treatments, and in these conditions the advantage of blue vitriol being cheaper, as compared with bouillies, entirely disappears. Blue vitriol sprayings have also the drawback of leaving no visible trace on the leaves, whilst bouillies enable the work to be controlled owing to the blue spots which they leave on the organs touched. In spite of these drawbacks blue vitriol is still used in 0·25 per cent. solution in Le Tarn, owing to the low cost of the spraying. To give adherence to blue vitriol Trabut advises to add mucilaginous substances to its solutions; the mucilage extracted from the prickly pears of the Barbary fig-tree, and galipot, a dry resin which exudes the whole length of the Algerian pines, previously dissolved in carbonate of soda. The galipot soap bouillie has the following composition: galipot, 1 lb. dissolved in $\frac{1}{2}$ lb. of soda crystals; blue vitriol, 1 lb.; water, 10 gallons. The bouillie with the Barbary fig mucilage basis is made thus: 3—5 lb. of the prickly pear of the Barbary fig are cut up and macerated in water. After extraction of the mucilage $\frac{1}{5}$—$\frac{1}{3}$ lb. of blue vitriol is added and the mixture made up to 10 gallons. These preparations effect a saving of 50—80 per cent. of blue vitriol and are cheaper in Algeria. They are to be recommended in countries where rain is rare, and where the number of sprayings necessary do not exceed those with bouillies. Experiments show that mildew may be contended against by spraying round the stocks with blue vitriol solutions; this salt would therefore possess serious advantages over bouillies. Unfortunately the doses required to obtain immunity are such that there can be no question of employing this treatment on the large scale. From experiments of Chmjelewsky it follows that blue vitriol has a deadly action on fructification. Beach and Bailey also found that it was deadly to pollen; 0·02 per cent. solutions lower its vitality, and it is killed when it comes in contact with 0·5—2 per cent. solutions. If the flower be open for some days only before the treatment the action of the blue vitriol is less injurious. Spraying with blue vitriol should thus be avoided during flowering if it is not desired to do great damage to the crop.

**Use of Mixtures containing Blue Vitriol.**—As the vine-grower already was accustomed to distribute flowers of sulphur with a bellows to contend against oidium, the operation of treating the mildew would have been greatly simplified if it had been possible to use blue vitriol in a pulverulent form mixed with sulphur. A great number of analogous mixtures have been compounded in different countries. They either contain blue vitriol mixed with powdered inert bodies, or are the elements of cupric bouillies with or without sulphur. With some rare exceptions, the adherence of these is much less than that of cupric bouillies which renders them liable to be carried off by the wind and by the first rain. It is also necessary to apply them in the dew of the morning, so as to render them a little more adherent. It will be seen, therefore, that these preparations cannot be regularly used except in moist countries, and that those which contain sulphur cannot produce on the oidium the categoric effect of sulphur alone used at a full heat. To increase the adherence of blue vitriol on the leaves it has been mixed with substances like talc, powdered coal, alumina, sulphate of lime, and sugar, or it has even been dehydrated and reduced to an impalpable powder by calcination. The latter preparations are the only ones of any real use in certain circumstances. Powders consisting of pulverized blue vitriol and various other bodies, mixed by grinding, are defective from the fact that projected on to the plant, the different densities of the products of which they are composed produces a separation, causing an irregular distribution of the blue vitriol. On the other hand, powders prepared like "cupric sulphosteatite" do not possess this drawback. Besides this drawback preparations which contain blue vitriol have all the defects of its solutions. These drawbacks make themselves felt when it is a question of using these powders against the cryptogamic diseases which affect delicate plants. The intense scorchings may have disastrous effects from the point of view of the yield of the plant. But the powders are easily distributed, and that is their great advantage. Their judicious use in special cases may save a vineyard from a sudden attack. The grower sometimes uses powders which enable him to dispense with bouillies, and when the vineyard is far from a dwelling, extensive, and without water, the carting of the necessary water for these bouillies is obviated. The appliances used are those utilized for sulphuration. However, as blue vitriol attacks leather, only bellows with exterior case can be used. In spite of the numerous disadvantages of powders many vine-growers have adopted the cupric sulphosteatite, which is the best of all these preparations. They use it at the same time as the bouillies, but this powder ought not in general to be used, except as a supplement to liquids, when the foliage is too thick that it prevents the uniform penetration of the bouillies. It is good to protect grapes for it penetrates more readily amongst the grapes as compact grains. Exact details will only be given of one of the preparations of this sort, the *cupric sulphosteatite*, compounded, like Fostite's powder (*Poudre Fostite*), of blue vitriol 10 per cent., talc 90 per cent. It is prepared by pouring on the talc in powder a saturated solution of blue vitriol. The resultant paste is dried, ground, and sifted. It is a bluish powder, which, owing to its lightness, penetrates as far as the interior of the vines with the most dense foliage. Used in the morning dew its adherence is so good that traces of it may be seen two months afterwards, even when violent storms have washed the leaves. Owing to this property it has given perfect results at Montpellier in assuring complete preservation of the vine. It has been especially recommended for destroying the mildew of grapes, for owing to its tenuity it penetrates everywhere, and the rapidity with which it can be applied enables the crop to be saved at the time of a sudden invasion. If it be desired to use it alone for mildew (which cannot be advised in spite of its properties, for Bordeaux bouillie is still superior), three applications are necessary, at the rate of 20—25 kilogrammes per hectare (17·6—22 lb. per acre). The first should be done eight days before flowering, the second five weeks after the first, and the third in the middle of July. If there be mildew in the neighbourhood, and late invasions to be feared, supplementary applications must be given. Dusting with powders containing blue vitriol are always injurious when they are made during flowering. Amongst the numerous preparations on the market at the time of the first publication of this treatise the following may be quoted as intended for making bouillies by mixing them with water, or to be pulverized such as they are by aid of a bellows. Their composition has been given by Barth, of Colmar :—

*Poudre "Coignet."*—Intimate mixture of 10 per cent. blue vitriol and 90 per cent. of gypsum, recommended by Klening and Wuthrich against *Phytophthora.*

*Sulphatine.*—Mixture of 73 per cent. sulphur, 7 per cent. blue vitriol, and 20 per cent. of lime; used in America against the black rot.

*Kupferschwefelkalk*, mark CuSCa.—Mixture of 70 per cent. of sulphur, 6 per cent. of blue vitriol, and 24 per cent of lime, recommended in

Germany by Schoyen to contend against mildew of the vine and oidium, and even *Phytophthora.* It has little adherence.

*Bordeaux bouillie celeste in a single powder.*—Mixture of 49·74 per cent. of blue vitriol, 15·1 per cent. of lime, and 35·16 per cent. of carbonate of soda.

*Skavinsky's Powder*, consisting of blue vitriol 20 per cent., lime 6 per cent., ground coal 74 per cent.

*Skavinsky's Sulphur.*—Blue vitriol 10 per cent., sulphur 50 per cent., lime 3 per cent., powdered coal 37 per cent. These two powders can only be used as supplementary applications when the foliage is too dense. They adhere badly.

*Kupfer Klebekalkmehl.*—1896—7 *Preparation.*—Blue vitriol 26, argillaceous clay 74 = 100 calcine. 1898 *Preparation*—22·5 per cent. of blue vitriol is neutralized by carbonate of soda and mixed with oxide of alumina and china clay. This latter preparation is very adhesive, and is used for making bouillies.

*Kupferzuckerkalkpulver.*—Calcined blue vitriol 40 lb., powdered slaked lime 50 lb., powdered sugar 10 lb. = 100 lb. mix.

*Cuprocalcit.*—Blue vitriol 20—25 lb. argillaceous carbonate of lime (? marl) 75—80 lb., per 100 lb. It is used in the dew, or as a bouillie, 1 lb. to 1½ gallons water. To strengthen its action it is recommended to add 1½ gallons of ammonia to 100 gallons of bouillie.

*Cupreina* possesses the composition of evaporated Bordeaux bouillie; used to make a bouillie, only gives imperfect results.

*Occidine.*—Mixture of blue vitriol (7·5 per cent.), green vitriol, sulphur, naphthalene, and carbonate of lime.

**Powders having the Composition of Bordeaux Bouillie, Burgundy Bouillie, and Eau Celeste, intended to be diluted with Water and used exclusively as Bouillie :—**

*Parasiticine.*—Mixture of blue vitriol 57 per cent., carbonate, and bicarbonate of soda.

*Antimildioidium.*—Mixture of blue vitriol 39 per cent., and carbonate of soda.

*Poudre Crochepeyre.*—Mixture of blue vitriol 53 per cent., and bicarbonate of soda.

*Gelatinous Cupric Hydrocarbonate.*—Mixture of blue vitriol 32 per cent., with carbonate and bicarbonate of soda.

*Bouillie d'Azur.*—Mixture of blue vitriol 48 per cent., and of bicarbonate of soda.

*Poudre Eclair.*—Mixture of blue vitriol 30 per cent., acetate of soda, lime, and acetic acid.

*Fostitebruhe.*—Mixture of blue vitriol 50 per cent., carbonate of soda and lime, tinted with aniline blue.

*Krystallazurin.*—Ammoniacal copper sulphate (70 per cent. of blue vitriol).

*Kupferpreparat Gmund.*—Emulsion of ammoniacal sulphate of copper (blue vitriol 20 per cent.) in water, and 11 per cent. of oil.

*Kupfer soda*, etc., etc.

**Use against Smut** (*Ustilagineæ*).—It follows from the mode of propagation of rust diseases that only the disinfection of the corn-seed and the dung can prevent the cryptogamic diseases of grain crops;

that no spraying can lessen, contend with, or prevent. Amongst chemicals used to disinfect seed-corn blue vitriol is one of the most powerful and the one in current use. The only drawback lies in the very decided sensitiveness of the grain to solutions of this poison. Different [chemical] agents have not the same effect on the germination of the seed. Chlorine water and lime water exert no injurious action; mineral acids retard germination without lessening the germinative capacity, whilst metallic salts, such as green vitriol, blue vitriol, sugar of lead, and others, are poisonous in small doses; a germination of 100 per cent. is only obtained by observing certain limits of concentration, special to each salt. In disinfection with blue vitriol a 0·5 per cent. solution must not be exceeded. More concentrated solutions yield the following :—

TABLE XXVII.—*Showing the Effect of Steeping Seed-corn in Solutions of Blue Vitriol of Different Strengths for Different Periods of Time.*

| Strength per cent. | Time of action. | Loss of grains per cent. | Strength per cent. | Time of action. | Loss of grains per cent. |
|---|---|---|---|---|---|
| 1 | 15 minutes | 10 | 2 | 1 hour | 46 |
| 2 | 15 „ | 14 | 2 | 2 „ | 54 |
| 2 | 39 „ | 28 | 2 | 3 „ | 59 |

The *strength* of the solution of blue vitriol and the *duration* of the steeping ought to be such that the blue vitriol *cannot enter* into the interior of the grain, but is confined to the disinfection of its exterior surface. As soon as the poisonous salt penetrates into the seed symptoms of poisoning are to be seen in the future plant. With solutions of different strength the following result was obtained :—

TABLE XXVIII.—*Showing the Effect on Height of Plant of Steeping Seed-corn in Solutions of Blue Vitriol of Various Strengths.*

| Strength per cent. | Time of steeping. | Height of the plant. | Appearance after one month. |
|---|---|---|---|
| Blank | — | 8–12 inches | Normal |
| 0·5 | 2 hours | 10–12 „ | |
| 1·2 | 2 „ | 8–10 „ | Dark colour. |
| 3·5 | 2 „ | 8 „ | |
| 10 | 2 „ | 6 „ | |

The greater the number of deep wounds sustained by the grain in threshing the more sensitive it is. When the grain is wounded nothing prevents the penetration of the copper solutions into the interior of the grain, and the embryo may be killed by a short immersion in a bath of blue vitriol. Ivans and Welter have made categoric experiments in this direction with grain wounded for the purpose.

TABLE XXIX.—*Showing Effect on Germination of Steeping Injured Grain in Water and in Solutions of Blue Vitriol.*

| Nature of injury to grains. | | Immersion in | Germination. |
|---|---|---|---|
| ⅓ cut from side opposite embryo | Check | Water | 90 |
| | Treated | 2 per cent. solution of blue vitriol | 44 |
| Epiderm of embryo slightly damaged | Check | Water | 40 |
| | Treated | 2 per cent. solution of blue vitriol | Nil |

The unwounded test samples were not injured by steeping from one to two hours in a 0·5 per cent. blue vitriol solution, and even a 1 per cent. solution when the action of the blue vitriol was stopped by a bath of milk of lime. Now it is a well-known fact that the threshing of grain in the threshing-mill damages about 30 per cent., whereas hand threshing [with the flail] does much less damage. This 30 per cent. is generally killed by steeping in a solution of blue vitriol, so that it is necessary to use, in general, 30 per cent. more seed to sow the fields when such corn-seed, disinfected by blue vitriol, is used. After a profound examination of the subject the greatest authorities agree on the superiority of the blue vitriol method, used rationally, over other methods of disinfection; it alone possesses the property of still acting after the sowing of the seed-corn within a certain radius of the latter. It protects them during the period the plant is vulnerable from the germs found in the soil, or which have been brought on to the land with the dung. From that point of view blue vitriol is superior to hot water, sodium sulphide, sodium sulphate, the disinfectant property of which is, however, analogous and the efficiency incontestable. However, blue vitriol, so as not to injure grain, must be used in a rational manner; the steeping should be as short as possible, and its action stopped at the right moment by converting it into an inert and insoluble derivative as soon as it has played its rôle of disinfectant. The methods recommended by Benedikt Prevost were not much altered by a deeper examination of the subject by Mathieu de Dombasle. By describing a practical method of disinfection the latter, however, largely helped to make this process general.

Here is his process: Dissolve 1 lb. of blue vitriol in hot water and make up the bulk to 20 gallons. Immerse the corn-seed into this bath in such a way that a layer of liquor, 4 inches in depth, remains above the seed. Stir several times and remove all the floating grains. After twelve hours' steeping remove the seed and spread it on a board. It must be turned frequently. By this prolonged immersion and stirring the air adhering to the grain, often with tenacity, is gradually displaced, and the liquid touches their whole surface. Corn-seed so treated does not keep. Like all grain moistened and swollen by steeping it heats and spoils; blue vitriol then exerts a deadly action on the seed and kills a large quantity. It is thus absolutely necessary to sow the corn-seed as soon as possible, and as soon as it is dry again. If the operation be commenced at 4 o'clock in the morning it is finished in the evening; the next morning the corn-seed disinfected by the blue vitriol is bagged up in sacks, conveyed to the field, and sown as soon as possible. In spite of all precautions, loss in using this process is unavoidable, for the blue vitriol is concentrated, in drying, around the grains, where it acts as a concentrated solution. To remedy this drawback weaker solutions have been tried. If grains are only immersed for fifteen minutes in a 0·5 per cent. solution they undergo no damage, and 99 per cent. germinate, often even before the untreated grain; after steeping for three hours the grain does not germinate until three days after the untreated grain (experiment on oats, variety Scotch White Superior).

Bloymeyer advises a still shorter immersion, carried out thus: Run the corn-seed into a basket and dip that for one minute into a 1 per cent. solution of blue vitriol. Drain and dry. If the time of steeping be considerably shortened, it is owing to the great concentration of the bath of blue vitriol. Herzberg found that the temperature of the blue vitriol solutions played a very important rôle. Below 8° C. the blue vitriol bath is, so to speak, without action on the spores of *Ustilago* (smut), whilst a solution at 24—26° C., even if it only contain 0·1 per cent. of blue vitriol, kills them instantly. This is explained by the fact that the spores are very resistant, but that the sporidia are very sensitive. By inducing their formation by a high temperature, the above result is obtained! Herzberg, therefore, recommends steeping for twenty-five hours in a 0·1 per cent. solution at 25° C. The spores of *Tilletia* (bunt) do not behave similarly. They rather appear to be more sensitive to cold solutions; the most favourable temperature is from 6—8° C. At that temperature a solution of 0·0004 per cent. prevents their future evolution. This fact was pointed out by Prevost as far back as 1807, who gave 6¼° and 7½° C. as the extreme temperatures to which these spores are most sensitive; at the ordinary temperature the immersion ought to last half an hour in a 0·05 per cent. solution; at a higher temperature these solutions, therefore, have no action. Wheat, therefore, infected with germs of *Tilletia* (bunt) ought to be disinfected, according to Prevost and Herzberg, at a low temperature, whilst barley and oat seed infected with *Ustilago* (smut) should be disinfected between 24° and 26° C. Treatment by blue vitriol alone is abandoned now, because it is too often deadly. An injurious action has been found on grain after steeping one hour in a 0·1 per cent. solution. The growth of the radicles is often affected to such a point that they do not form although the plumule may be long enough. When the radicle emerges its point is brown, and remains sickly for some time. To avoid this annoying action of blue vitriol, produced after steeping (an action which is always dangerous because the adherent liquid becomes concentrated), a second steeping must be given, capable of removing this secondary action from the blue vitriol. Kuhn was the first to wash the disinfected grain and immerse it in a 6 per cent. milk of lime. This method, which suppresses all the drawbacks of blue vitriol, has met with a wide response. It is in common use in Germany. Steglich places the corn-seed in a basket, dips it into the blue vitriol solution, takes it out and at once dips it into a solution of carbonate of soda. The copper carbonate which forms an insoluble layer round the grain is without any injurious action on it, but it is a very effectual protection against infection, which may occur after sowing. Hollrung altered this method; he steeps the grain in a vat containing only a 0·3 per cent. solution of blue vitriol. After stirring the grain for four hours he takes it out and washes it for thirty minutes in a 0·4 per cent. solution of milk of lime. The seeds are then spread on the floor in a thin layer and frequently turned. Each operation should be done in warm weather. In spite of all experiments on steeping, on the concentration of solutions, and on the temperature, Kuhn's process is used in actual practice, the steeping in a blue vitriol bath being followed by a passage through milk of lime. The dangers of too strong solutions being thus much diminished reversion was made to solutions of 0·5—1 per cent. used in immersions of short duration. This operation, always long with dilute solutions, is thus greatly shortened. The following method most used in France was popularized by the Minister of Agriculture. Dissolve 50—100 grammes (772—1543 grains) of blue vitriol in 10 litres (2·2 gallons) of water [1] and dissolve this in a vat containing 1 hectolitre (2¾ bushels) of corn-seed, then add water until the grain is covered with a layer of liquid 4 inches deep. Stir the mixture. Remove the seed which float, then drain the remainder in a basket. After an hour dip the grain into fresh water, and dust with slaked lime (chaux fusée). To prevent any delay in germination Bernard advises a steep of the following composition: 50 grammes of blue vitriol (772 grains), 300 grammes of nitrate of soda (4632 grains), and 300 grammes of superphosphate (4632 grains) in 10 litres of water. After a short immersion in this steep the grain is pralined with ashes or slag. Seed-corn so treated has always shown a certain advance in its growth, and given higher yields because the plant finds after brairding a zone rich in nutritive substances. An analogous result is obtained by the repeated spraying of wheat in a heap. When all the grain is well impregnated with blue vitriol the heap is dusted with slaked lime. This method has the advantage over immersion of precipitating around the grain a strong layer of hydrated oxide of copper, which adheres very well to the surface and prevents ulterior infection by contaminated dung, but this process requires much handling for it requires continual shovelling.

In spite of the perfection of the processes in use, even if there be no doubt of the superiority of this treatment over others, with the same end in view, loss of grain is inevitable, and it is necessary to increase from 20—30 per cent. the amount of seed sown to prevent too thin sowing, although in practice there is only one treatment for all the cereals.

*Barley.—Hordeum vulgare* is infested by *Ustilago hordei*, Bref., and *Hordeum distichum* by *Ustilago Jensenii*, Rost.

These experiments were made by Hollrung in using Kuhn's method of disinfection, 0·5 per cent. blue vitriol and 6 per cent. of milk of lime.

*Oats.—Avenæ sativa* is infested with *Ustilago avenæ*, Rost.; *Avenæ elatior* is infested with *Ustilago perennans*, Rost.

Disinfection by Hollrung's method does not cause this diminution in the crop so perceptible in Kuhn's method.

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[1] That is to say, at the rate of 5 lb. to 10 lb. of blue vitriol in 100 gallons of water, and of this solution use 1 gallon for every bushel of seed-corn.—Tr.

TABLE XXX.—*Showing Effect on Germination of Seed Barley of Steeping in Solutions of Blue Vitriol of Various Strengths.*

| Grain. | Duration of steep. | Strength of steep. Per cent. | Germination of grain. Per cent. |
|---|---|---|---|
| Treated | 24 hours | 0·5 | 88 |
| ,, | ,, | 1 | 64 |
| ,, | ,, | 2 | 48 |
| ,, | ,, | 5 | 35 |
| Check | — | — | 98 |

TABLE XXXI.—*Showing Delay in Germination by Kuhn's Treatment.*

| Soil. | Grain. | Germination per cent. | | | |
|---|---|---|---|---|---|
| | | 3rd Day. | 7th Day. | 14th Day. | 26th Day. |
| Sand | Untreated | 60⅓ | 95 | — | — |
| ,, | Treated | 27⅓ | 97⅓ | — | — |
| Soil | Untreated | — | — | 45·7 | 86·7 |
| ,, | Treated | — | — | 60·4 | 89·0 |

TABLE XXXII.—*Showing Effect of Blue Vitriol Pickle on Crop of Barley.*

| Grain. | Number of ears. | Rust. | Weight of grain. Grammes. | Weight of straw. Grammes. |
|---|---|---|---|---|
| Untreated | 173 | 4 | 104·5 | 185·5 |
| Treated | 243·7 | — | 161·9 | 184·2 |

TABLE XXXIII.—*Showing the Sensitiveness of Seed Oats to Blue Vitriol Pickle* (Gaillot).

| Grains. | Duration of steep. | Strength of the steep, per cent. | Germination of the grain, per cent. |
|---|---|---|---|
| Treated | 24 hours | 0·5 | 45 |
| ,, | 24 ,, | 1·0 | 20 |
| ,, | 24 ,, | 2·0 | 10 |
| ,, | 24 ,, | 5·0 | 0 |
| ,, | 6 ,, | 0·5 | 98 |
| ,, | 30 minutes | 1·2 | 98 |
| Untreated | — | — | 98 |

TABLE XXXIV.—*Showing the Delay in Germination by Blue Vitriol Pickling of Seed Oats* (Kuhn's method).

| Soil. | Grains. | Germination, per cent. | | | |
|---|---|---|---|---|---|
| | | 4th Day. | 7th Day. | 14th Day. | 26th Day. |
| Sand | Untreated | $76\frac{1}{3}$ | $93\frac{2}{3}$ | — | — |
| ,, | Treated | 43 | $94\frac{1}{3}$ | — | — |
| Soil | Untreated | — | — | $51\frac{1}{3}$ | $93\frac{1}{3}$ |
| ,, | Treated | — | — | $54\frac{2}{3}$ | $88\frac{2}{3}$ |

TABLE XXXV.—*Showing Effect of Kuhn's Blue Vitriol Pickling of Seed Oats on the Oat Crop* (Hollrung).

| 100 Grains of seed oats. | Number of ears. | Rust. | Weight of grain in grammes. | Weight of straw in grammes. |
|---|---|---|---|---|
| Untreated | $89\frac{2}{3}$ | 5 | 107·7 | 157·1 |
| Treated | $77\frac{1}{3}$ | — | 90·5 | 205·8 |

*Wheat.*—*Triticum sativum* is invaded by *Ustilago Tritici* Jensen (smut of wheat); *Tilletia caries*,[1] Tul.; *Tilletia levis*, Kuhn (stinking smut, bunt of wheat.)—It is particularly on this fungus that Prevost tested the action of blue vitriol. By disinfecting "spotted" grain, that is to say, covered with spores of *Tilletia* (bunt), he obtained: Spotted non-treated grain, 486 per 1000 of rusted ears; spotted treated grain, 8 per 1000 of rusted ears, after steeping half an hour in a 1·2 per cent. solution. Whilst blue vitriol used alone greatly reduces the germinative capacity of the barley, this treatment of Kuhn has not that drawback. Grain treated with 0·5 per cent. solution of blue vitriol, however, does not show it if sown immediately (Grassmann).

TABLE XXXVI.—*Showing Reduction in Germinative Capacity by Delay in Sowing after Pickling with Blue Vitriol.*

| Grain. | Loss per cent. in germinative capacity. | Total germination, per cent. |
|---|---|---|
| Untreated grain . . . . . . | 95·75 | 98·6 |
| Treated grain sown 1st day after disinfection | 93·5 | 97·5 |
| ,, ,, 2nd ,, ,, | 91·0 | 97·25 |
| ,, ,, 3rd ,, ,, | 86·25 | 95·25 |
| ,, ,, 4th ,, ,, | 81·25 | 95·75 |
| ,, ,, 10th ,, ,, | 66·6 | 95·75 |

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[1] *Tilletia caries* (Bunt or Stinking Smut of Wheat).—Fungus analogous to *Ustilago* (smut) which only attacks wheat grain. At harvest time the grains, which do not show any distinct outside indication, are filled with a brown powder which exhales a fœtid odour. This dust consists of spores. The spores germinate in a moist medium and the germination filament pierces the stem of the wheat at the moment it starts to grow.

Owing to the similarity between the smut disease of different plants, the methods found efficacious for smut of cereals may be employed in all cases. The steeping of sorghum seed against smut with copper sulphate is extensively carried out in India.

*Ustilago Panici-miliacei*, Wint. (smut of millet).—The treatment of the grain by Kuhn's method, one hour's steeping in a blue vitriol solution of 0·5 per cent., followed by a 6 per cent. milk of lime, prevents the infection of the young plant (plantule) by spores adherent to the seed. The same delay in germination was observed by Aderhold, who also found that 86 per cent. of the seeds treated germinated, showing 0·4 per cent. of rust against 90 per cent. of the untreated seed with 7·45 per cent. of rust. It is an excellent palliative, but it is better still to roast the spores by letting them fall through a twig broom held 1 metre above a very light straw fire.

*Ustilago Maydis*, Corda (smut of maize), cannot be avoided as surely as all the other rusts, because the spores of this fungus are of themselves able to penetrate into the adult plant through the newly formed leaf. In spite of this pecularity blue vitriol is used with success, but it does not prevent future infection of the plant.

*Urocystis cepulæ*,[1] Frost (smut of the onion.)—Although the disease may be suppressed by rejecting all rusty stocks on transplanting, Mohr points out the good effect of spraying with a 3 per cent. solution of blue vitriol.

*Puccinia* (rusts).—Three different species are found on grain crops: *Puccinia graminis*, Pers. (common or linear rust); *Puccinia Rubigo-vera*, Wint. (spotted mildew); *Puccinia coronata*, Cord. (rust of oats).—The development of rust differs totally from the method of propagation of smut and bunt. It is impossible to prevent rust of corn in the same way and at the same time as smut diseases by simple disinfection of the seed-corn. Their methods of multiplication are so varied that it is, so to speak, impossible to create an obstacle to the propagation of these diseases by chemical means so as to hope for a radical effect, curative or preventive, by the means which render such excellent service in combating other diseases. The means of action are very limited, and direct attack is impossible. It is only from an instructive point of view that the results obtained by spraying with blue vitriol preparations are given. Wuthrich has shown that the uredospores, though much less resistant than the spores of most fungi, are yet destroyed by a 0·124 per cent. solution of blue vitriol; their sensitiveness to this salt begins at the dose of 0·00124; at 0·0124 per cent. germination is prevented. Hitchcock and Carleton found a 0·1 per cent. solution prevented their germination without killing the spores. H. de Vilmorin and F. Douillet found that plants of white March Chiddam wheat, treated several times with blue vitriol sprays and afterwards conveyed close to mildewed wheat, were not attacked, whilst in the same conditions untreated plants were invaded. But this treatment, difficult even when the wheat is in the blade, becomes impracticable when it is in the ear. It is owing to this difficulty that this process has miscarried, although it has been found efficient in experiments on the large scale in Australia, and in the Côte d'Or. The dose required to kill uredospores is much greater than to destroy the zoospores of mildew of the vine, and it is surprising that spraying has such perfect results. In our opinion, blue vitriol would act in this case more especially as a stimulant, producing more active and vigorous growth, enabling the plant to oppose a greater resistance to invasion by this fungus, and thus to acquire a sort of immunity.

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[1] Urocystis cepulæ (smut of the onion).—This smut attacks the bulbs of the onion when very young and kills them. Its presence is indicated by obscure spots on the leaves of the young onion, whilst in germination the leaves split longitudinally and show a withered tissue covered with black dust.

*Helminthosporium gramineum*, Eriks. (browning of barley).—Kolpaon Raon insists that Kuhn s process is an excellent means of preventing this disease.

*Claviceps purpurea* (ergot).—The conidia of this fungus do not develop in a solution of blue vitriol of 0·0124 per cent.

*Dematophora necatrix* (root rot of the vine).—Dufour recommends blue vitriol to prevent this disease. When the roots are completely invaded by the mycelium the plant is condemned, and ought to be destroyed, the more so as the organs of propagation, the conidiophores, charged with conidia, appear to develop, especially after the death of the tree. By tearing up the tree and carefully exterminating the débris of the roots and the ropes, the propagation of the disease is prevented. To destroy the spores, or the mycelium, of which the soil may retain a fraction, the latter is watered with a 3 per cent. solution of blue vitriol. Before planting new vines 1—2 litres of this same solution is poured into the holes. Within a radius of 2—3 rows the stocks already attacked or not are stripped in the spring and freely watered with this solution; 100—150 grammes of blue vitriol in powder may likewise be spread per stock. The result is not always complete and visible the first year, and it is sometimes necessary to repeat this treatment two years running; the results obtained in these conditions are, however, very positive.

*Guignardia Bidwelli*, Viala and Ravaz (black rot of the vine).—From the first appearance of this disease, when it was found that it did not appear at first on the fruit but only the leaves, which then became hotbeds of infection for the grapes, attempts were made to stop its evolution by repeated sprayings of blue vitriol. The experiments made at Ganges were not very satisfactory, whilst Bordeaux bouillie later on gave the most perfect results. Rathey and Havelka have proved that the spores are killed after thirty hours' steeping in a blue vitriol solution of 0·5 per cent., and they recommend the disinfection of the buds of the vine against black rot by total or partial immersion in a 1 per cent. solution for one hour. Their experiments succeeded perfectly, and proved also that the steeping of the buds for an hour in 1 per cent., 5 per cent., and even 10 per cent. solutions of blue vitriol, did not lower their vitality; the lower section seems as if it could no longer form a cushion to remedy this drawback: it suffices to cut $\frac{3}{4}$ of an inch below the buds before transplanting them.

*Gloeosporium ampelophagum*, Sacc. (grape rot).—Sorauer recommends blue vitriol in place of green vitriol to combat this fungus in winter. Instead of coating the stock with a 50 per cent. solution of green vitriol a 20 per cent. solution of blue vitriol is used. This practice is excellent, but more costly than Slavinsky's.

*Gloeosporium nervisequum*, Sacc. (disease of the leaves of the plane-tree).—Nobele recommends, to prevent this disease, to spray with a 3 per cent. solution of blue vitriol in the month of April and in the month of May before the tree is in leaf.

*Fusicladium pirinum*, Fuckel (pear scab); *Fusicladium dentriticum*, Fuckel (apple scab).—These diseases may be combated by spraying with blue vitriol solutions. By judicious spraying at the right moment the conidia formed on the cushion of the conidiophores of the leaf are destroyed, and prevented from planting themselves on the fruits. Oliver found that the spores were destroyed by blue vitriol. Used on large scale in 0·5 per cent. solution by Goff, he greatly diminished these diseases. Mohr recommends a 3 per cent. solution for the same purpose. These sprayings should be done before spring, in the month of April. Blue vitriol has not such a radical action as Bordeaux bouillie. The latter may, if used before the expansion of the buds, completely prevent these diseases.

*Morthiera Mespili*, Fuckel; *Entomosporium maculatum*, Lev. (leaf scald).—This disease of the leaves of the pear may be prevented, according to Mohr, by spraying with a 3 per cent. solution of blue vitriol before the formation of the leaf in April and May.

*Disease of the Poppy* (œillet).—Mangin advises to prevent this disease to steep the buds in a 0·12 per cent. solution of blue vitriol before transplanting.

*Beet Diseases.*—To prevent these diseases, transmitted by spores infecting the seed, disinfect the seed with blue vitriol, which gives good results against—

*Pleospora putrefaciens*, Franck (rot of the heart of the beet) and *Phoma tabifica*, Prill. and Dell. (*Phoma betæ*, Franck) (disease of the leaf-stalk of the beet).—Carlson advises washing the seed in a 1—2 per cent. solution of blue vitriol. Linhart advises steeping for twenty-four hours in a 2 per cent. solution; although this diminishes the germination of the seed a little, yet Franck recommends it. It also removes the larvæ of *Agriotes lineatus*, *Hypomyces magnus* (mole disease of the mushroom). It requires three to seven days' steeping in a 2 per cent. blue vitriol solution to kill the spores. This disease is not circumscribed by this salt.

*Black Disease of the Clematis.*—To prevent this disease produced by a slug, copious spraying with solutions of blue vitriol every fortnight before transplanting have a good effect.

**Use of Blue Vitriol against Worms and Snails.**—Snails and slugs are as sensitive to blue vitriol as to green vitriol. If they pass over a surface sprayed with blue vitriol they soon die. The hatred of snails for blue vitriol is such that to remove them it suffices to stretch a cord, 1½ inches wide, steeped for twenty-four hours in a 10 per cent. solution. This cord ought to touch the soil; it forms an insurmountable barrier. This method is practised in Italy. Bignon has also observed that the vitriolizing of ropes and trellises removes slugs.

# CHAPTER XIV

## COPPER HYDRATE—BORDEAUX BOUILLIE—BURGUNDY BOUILLIE—COLLOIDAL COPPER HYDROXIDE

**Copper Hydrate (Bordeaux Bouillie).—Preparation.**—By precipitating a soluble salt of copper, by caustic alkali, or by milk of lime.

$$\underset{\substack{\text{Copper}\\ \text{sulphate.}}}{\mathrm{CuSO_4}} + \underset{\substack{\text{Sodic}\\ \text{hydrate.}}}{\mathrm{2NaOH}} = \underset{\substack{\text{Cupric}\\ \text{hydrate.}}}{\mathrm{Cu(OH)_2}} + \underset{\substack{\text{Sodic}\\ \text{sulphate.}}}{\mathrm{Na_2SO_4}}$$

$$\underset{\substack{\text{Copper}\\ \text{sulphate.}}}{\mathrm{CuSO_4}} + \underset{\substack{\text{Calcium}\\ \text{hydrate.}}}{\mathrm{Ca(OH)_2}} = \underset{\substack{\text{Copper}\\ \text{hydrate.}}}{\mathrm{Cu(OH_2)}} + \underset{\substack{\text{Calcium}\\ \text{sulphate.}}}{\mathrm{CaSO_4}}$$

The Bordeaux bouillie is prepared by the second reaction; it is a mixture of hydrated oxide of copper and sulphate of lime, and generally contains an excess of lime. Its composition and its concentration vary much.

*Bordeaux Mixture.*—The British Ministry of Agriculture recipe for Bordeaux mixture (bouillie) is as follows: copper sulphate 13 oz., best quicklime (90 per cent. CaO) 13 oz., water 10 gallons. Dissolve the copper sulphate in water in a wooden receptacle, at the rate of 13 oz. to 1 gallon. In another vessel slake the lime to a fine powder with a little water; add water to dilute to 9 gallons, stirring well meantime. Then pour in the copper sulphate solution. Stir for five minutes and use as soon as possible, certainly within twenty-four hours. *Bordeaux bouillie* is recommended by the Ministry of Agriculture as the best fungicide for spraying against pear scab (*Venturia pirina*) and against "cherry leaf scorch" (*Gnomonia erythrostoma*) and apple scab (*Venturia inæqualia*). For spraying against potato blight (*Phytophthora infestans*) the British Ministry of Agriculture proportions for a 1 per cent. solution are 4 lb. of copper sulphate, 2 lb. of freshly burnt lump quicklime and 40 gallons of water. For a 2 per cent. mixture, which, however, has little more fungicidal value, the quantities of copper sulphate and quicklime are doubled.

*Burgundy Bouillie.*—The British Ministry of Agriculture method of making Burgundy mixture (bouillie) for spraying potatoes against blight (*Phytophthora infestans*) is as follows: *For spraying one-third of an acre* (*say* 50 *rods*). (1) Dissolve 4 lb. of sulphate of copper in 5 gallons of water in a barrel (iron or zinc vessels must not be used) capable of holding 40 gallons, then make up to 35 gallons. (2) Dissolve in another vessel in 5 gallons of water 5 lb. of washing soda (previously broken up into small pieces if necessary). (3) When the soda is *completely* dissolved, add (2) to (1), stirring vigorously meanwhile. (Both copper sulphate and soda should be of fully 98 per cent. purity.) Where smaller areas are to be sprayed, barrels, capable of holding 10 gallons may be used; in that case, the quantities of copper sulphate and soda given above should be reduced each to ¼, namely, 1 lb. of sulphate of copper and 1¼ lb. of washing soda. The above formula gives what is known as 1 per cent. Burgundy mixture, *i.e.*, 1 per cent. of copper sulphate is used in its preparation. The use of Burgundy mixture of double this strength, *i.e.*, 2 per cent., is sometimes advocated, but results indicate that there is little to be gained. A Burgundy mixture of the following composition has been used with excellent results at the Royal Horticultural Society Gardens, Wisley: copper sulphate 2½ lb., sodium carbonate 2¾ lb., water 12 gallons. If a smaller quantity of the mixture be required, the proportions would be: copper sulphate 9¾ oz., sodium carbonate 11 oz., water 3 gallons. The addition of a small quantity of milk of lime to the above mixture was found to be of advantage in facilitating the adherence of the spray to the buds. Against the "Die-back" disease of gooseberries (*Botrytis cinerex*) the proportions recommended are 8 lb. copper sulphate, 8 lb. of quicklime and 100 gallons of water.

**Preparation of a Normal Bordeaux Bouillie.**—A solution of blue vitriol is prepared on the one hand, and on the other hand a milk of lime carefully rubbed up with water.

1. *Blue Vitriol.*—This salt should be as pure as possible. It should be dissolved in wooden, copper, glass, or stoneware vessels; those of tin and iron should be avoided, as these metals decompose blue vitriol. To facilitate solution of blue vitriol it is placed in a basket or pocket of wire gauze, in a vessel filled with rain water, so that it dips into it completely, but as near the surface of the liquid as possible. Solution is complete in twelve hours. If pressed for time blue vitriol may be dissolved in a little warm water and this solution run into the receiver containing the remainder of the water required to make the bouillie. It is necessary to use a *cold* solution of blue vitriol in making the mixture, for with hot solutions there would be formed, along with the granular hydrated oxide of copper, some inert black oxide of copper.

2. *Milk of Lime.*—The lime should be fat lime in lump. This quicklime is slaked by adding water gradually. As soon as it is slaked it is beaten up in cold water to form milk of lime. This milk of lime is passed through a fine sieve, to separate the impurities present in all limes. To obtain a fine, gelatinous, homogeneous precipitate, having a maximum adherence to the leaves it is advisable to mix these two liquids as follows: The milk of lime is run slowly, in a fine stream, into a cold solution of blue vitriol, stirring constantly, or, better still, run the two solutions simultaneously and slowly into a third vessel, stirring the latter energetically. Theoretically 14 lb. of pure quicklime suffice to precipitate 62½ lb. of pure blue vitriol. Practically the amount of lime used is always greater, because the lime is never pure. The amount of lime varies, therefore, according to its purity, from 1—3 lb. of lime to 3 lb. of blue vitriol. The most advisable quantities to form an active bouillie are 10 lb. of blue vitriol in 50 gallons of water, and 3½—10 lb. of lime, dissolved in 50 gallons of water. The mixture formed by these two solutions is termed a 1 per cent. solution.

**Properties of Copper Hydrate.**—Copper hydrate is a pale blue precipitate, which is more fine and gelatinous the lower the temperature at which it is precipitated. It is almost insoluble in water at all temperatures; it is converted in hot water into black copper oxide, CuO. It is, however, soluble in mineral and organic acids.

**Properties of Bordeaux Bouillies.**—A Bordeaux bouillie prepared in good condition, should have the following properties: *It should be neutral or slightly alkaline; it must never contain an excess of blue vitriol.* To ascertain its composition a little of the bouillie is filtered, or allowed to settle. The limpid liquid collected should not be tinted blue (which would point to unchanged blue vitriol), but should be absolutely colourless. It should give no reaction with litmus paper, nor an alkaline reaction with turmeric paper. Another and still better method of showing the presence of small quantities of undecomposed blue vitriol consists in placing a little Bordeaux bouillie in a saucer and to pour on it a few drops of yellow prussiate. The presence of blue vitriol is revealed by a red coloration of the bouillie. A blade of a knife dipped in a bouillie, still containing blue vitriol, is covered with a deposit of metallic copper.

*The bouillie must be tested and respond to the tests in the right way, otherwise it is unfit for all the purposes for which it is intended.*

Too often the sprayings eventually burn the leaves and the young parts of the plant. They are due, with few exceptions, to faults in the composition of the bouillie. Traces of blue vitriol, not converted into cupric hydrate, suffice to cause these burns. As a preventive of cryptogamic diseases the bouillie must be as adherent as possible, so as to prolong its action on the surface of the vulnerable organs of the plant.

Adhesion depends on several factors: (1) The blue vitriol should be precipitated cold, as above described, by milk of lime. (2) The more pure (fatty) the lime, the more adherent the bouillie. (3) The more freshly prepared, the more adherent the bouillie. (4) The bouillie is the more adherent the more nearly neutral it is; that is, without an excess of lime. Although it is not injurious to vegetation, it is well to estimate exactly the quantity of lime to use in preparing the bouillie. Lime in excess has, moreover, the drawback of retarding the action of the Bordeaux bouillie on the germs of cryptogamic fungi. Cupric hydrate as deposited on the leaf of a plant is, so to speak, insoluble, and thus inert towards the spores in contact with it. To become active it must be converted, in contact (1) with the air, into copper carbonate, soluble at the rate of 40 milligrammes in a litre of water containing carbonic acid; or (2) with carbonate of ammonia, or be dissolved by the juice exuded on the surface of the leaves. Whichever of the two cases occurs, or both together, it will be seen that cupric hydrate mixed with a large excess of lime will not have such a rapid action as in the absence of lime, the latter having a great affinity for carbonic acid. It also neutralizes organic acids, and in many cases, as the action of the Bordeaux bouillie cannot be retarded, to stop infection an excess of lime should be avoided. An excess of lime delays the action of Bordeaux bouillie one to ten days, according to the amount of lime used. Bordeaux bouillie, when well prepared, combines all the properties required in an anticryptogamic bouillie, and all the substances added to increase its toxic action on spores or adherence to the leaves are useless if it be not conscientiously prepared and used immediately afterwards. To popularize its use the trade has prepared powders, having exactly the composition of a normal bouillie, which only require mixing with water to produce a Bordeaux bouillie. The greater number of these powders yield bad bouillies; they may undergo decompositions, rendering them unfit for the preparation of a proper bouillie, and yield heterogeneous bouillies, in which undissolved blue vitriol is plastered up with a layer of sulphate of lime. Not only does it become difficult to use them with the spraying machine, but they have all the defects of badly made bouillies. If applied by the bellows the same thing occurs on the leaf, the chemical reaction is incomplete, the blue vitriol acts as such and causes burns. Nothing, therefore, can replace a bouillie made on the spot by one's self, with the precautions indicated above, and no similar preparation can be either so adherent or so efficient.

**Action of Cupric Hydrate on Plants.**—Insoluble copper salts appear to be absorbed to as great an extent by the roots as by the aerial organs of the plant, and cause poisoning. If the doses absorbed are infinitesimal no poisoning occurs. The copper salts then exert a salutary stimulating effect. It was thus essential to find a salt of copper which in contact with plants was only absorbed in infinitesimal doses, simultaneously stimulating the growth of the plant and destroying cryptogamic disease. It was found that cupric hydrate fulfilled these conditions best and that Bordeaux bouillie could practically fill that rôle. The cupric hydrate deposit formed on the leaves is very adherent, insoluble in water, and barely soluble in water containing dissolved carbonic acid or carbonate of ammonia. It lets the plant absorb it in infinitesimally small doses, which might escape detection in analysis, but which none the less exist since their presence in the leaf renders it so far immune to cryptogamic diseases, and especially vigorous, analogous to the condition realized by spraying the soil with blue vitriol. Leaves of the potato plant treated with Bordeaux bouillie become thicker and more vigorous, the chlorophyll increases, assimilation is more active, and the starch content of the tubers greater. Galloway got the same results with fruit trees. Young plants sprayed three to four times a year showed much more rapid growth, and preserved their leaves into the winter. It is very evident since this cupric treatment gives to the leaf a great assimilative force, and that it prolongs this into the winter, the young tree will have grown more rapidly than trees which prematurely shed their leaves by degeneration induced by parasites. Numerous comparative trials have shown in an irrefutable manner that young fruit trees in the nursery, treated with four to seven sprayings with a 2 per cent. Bordeaux bouillie, show an increased height, and yield crops largely compensating for the cost of this treatment. In nurseries young pears treated three years in succession attained a height of 5 feet to over 7 feet, and had a diameter of 7½ inches, whilst untreated pear trees of the same age, placed in the same conditions, only reached 2—3 feet in height and only 2¼—3½ inches in diameter. With young pear-trees the experiments were not so decisive, as their leaves are often sensitive to Bordeaux bouillie. The same observations have been made as regards the vine. To obtain a richer growth large doses of copper are not necessary. It is now believed that 0·25 per cent., and even 0·1 per cent., do the same good as 1 per cent. bouillies. Bessler, by one spraying of Bordeaux bouillie on haricots when tilling the ground, followed by one spraying of the young plant, obtained a 50 per cent. better crop than on untreated plants. It is only the stimulating and preventive treatment which gives this result.

We must not wait until plants show signs of cryptogamic diseases before treating them, but prevent such by destroying the germs. Some plants, however, do not stand the deposition of hydrated oxide of copper on their leaves without injury, because, owing to the exceptional nature of the foliageous tissue, it is absorbed in too great quantity, and then acts like blue vitriol. The plants which behave thus are apple-trees, peach-trees, and some varieties of rose bushes. On these trees the treatment is followed by the fall of all the leaves reached by the Bordeaux bouillie, or at least by burns which cause holes in the leaves. Müller and other observers found that these burns especially occur when the plant is exposed to the sun, and that plants in the shade do not show these injuries. Trials, to see if lime contributed to the injurious action of the Bordeaux bouillie, have shown the contrary. Whilst a 4 per cent. milk of lime has no injurious action on Bordeaux bouillie, a 0·5 per cent. solution of blue vitriol and a 1 per cent. milk of lime burnt the leaves as much, and even more, than a bouillie with 4 per cent. of lime and ·05 per cent. of blue vitriol. The peach-tree—the most sensitive to Bordeaux bouillie—behaves towards it as towards pure blue vitriol. The treatment is followed in most cases by the fall of the leaf; but after this treatment the peach, nevertheless, shows the same recrudescence in its vitality as soon as the new leaves come forth, so that in the end this treatment is as salutary as for other trees. The action of cupric hydrate is thus analogous to that of green vitriol; in a general way this salt increases the chlorophyll, and consequently the assimilation; it thus prolongs the vitality of the deciduous organs of the plant. Green vitriol, being present in commercial blue vitriol to at least 2 per cent. as an impurity, it was imagined, first in America, then in Germany, that the strengthening effect produced by the bouillie was only due to this green vitriol, for which reason Aderhold advised the use of a Bordeaux bouillie of the following composition: Blue vitriol 1·9 per cent., green vitriol 0·1 per cent., lime 2 per cent. Guocdenovic, who examined these bouillies, found that they had not any greater stimulating action than an ordinary bouillie of 2 per cent. blue vitriol and 2 per cent. lime. The dose of green vitriol required to produce an analogous physiological effect to that produced by spraying with Bordeaux bouillie is 0·5 per cent. The plant must also come in contact with the soluble salt, the green vitriol, the hydrated oxide of iron deposited on the leaves having produced no result, except as a 3 per cent. bouillie. A bouillie containing 0·1 per cent. of green vitriol in an insoluble form cannot therefore act on the plant and strengthen the action of the Bordeaux bouillie, far less the impurities, which only bring 0·04 per cent. of hydrated oxide of iron in contact with the leaves. It must therefore be admitted that blue vitriol acts in the same way as green vitriol, but it is about ten times more active in much smaller doses. Then comes the problem of the absorption of the copper by the leaves when this product is deposited thereon in an insoluble form. Although the increase of the chlorophyll may be easily determined, and the action of the copper on the plant be undeniable, it is very difficult to find in the leaf, in consequence of this treatment, abnormal quantities of copper. It is thus owing to imperfections in our methods of analysis that it is generally believed that copper is not absorbed by the leaf. Sestini has, however, found more than normal amounts of copper in vitriolized vines. Analyses of this sort are very difficult and very delicate to make, for many reagents, even distilled water itself, may contain the infinitesimal doses of copper sought for in the plants. Nägeli, from experiments he made on the alga *Spirogyra*, concluded that a plant which did not show any symptom of poisoning could not have absorbed copper, as the latter, absorbed by a cell, kills it, and since the favourable action of copper is undeniable, it must act at a distance. These conclusions raise hypothetical questions which we cannot discuss. It will be sufficient to point out some facts which plead in favour of absorption, and which show that the plant is perfectly capable of dissolving insoluble copper derivatives deposited on the surface of the leaves, and of absorbing them in minimum quantity. Barth was the first to express the opinion, so disputed by Droop and Wortmann, that cupric hydrate is dissolved by the exudations of the leaf. Clark has given considerable support to this hypothesis. Having observed that animal and vegetable substances were capable of dissolving cupric hydrate, an observation which Swingle had already made as regards the secretions of certain fungi, he concluded that certain organic compounds contained in the juice of plants may dissolve cupric hydrate. To verify this hypothesis he experimented on the leaves of the peach-tree, which are the most ready to absorb copper. In fact, these leaves covered with a layer of Bordeaux bouillie, give up to the water lying on them for some time a quantity of dissolved copper capable of killing the spores of fungi. When there is dew on a leaf, two liquids, separated by a membrane, are present, the one is charged with soluble bodies, while the other is pure water. It follows that exosmosis of the leaf may occur towards the dew. The organic substances thus in contact with the deposit of cupric hydrate may dissolve not only the quantities required to kill the germs fallen on the leaves, but also those indispensable to the plant itself. Thus the dose of soluble copper collected in this way by Clark killed the *Spirogyra*. The water thus contained more than 0·000001 per cent., an amount perfectly sufficient to stimulate the plant. From the deadly effect of blue vitriol on the cells of plants, and the difficulty with which this salt is absorbed, it does not necessarily follow that the insoluble salts deposited on the plant behave in the same way. Those which are insoluble and neutral would have no action on the plant, nor on the spores of fungi, if they were not rendered soluble and assimilable by conversion into a soluble organic salt, which may be absorbed by the leaf and destroy the spores on the surface of the organs of plants. The amounts of soluble copper salts required to stimulate the plant are so small, and those which suffice to preserve it from invasion, by injurious fungi, are so infinitesimal, that their presence in the organs of the plants which have been in contact with the copper cannot be chemically demonstrated; but the principle of absorption cannot be denied, since the constant presence of copper in the ashes of the plants treated has been determined by analysis.

**Action of the Bordeaux Bouillie on Fresh-water Algæ.**—Green algæ behave towards copper like all green plants, but they are much more sensitive to its action, probably because in the experiments all the body of the plant dips into the poisonous solution. This plant is perfect for allowing the observer to follow progressively the action of blue vitriol on the living cell. Nägeli examined and determined the precise action of blue vitriol on *Spirogyra*. It was desired to determine, likewise, how this alga behaves towards Bordeaux bouillie. Rumm undertook this work and examined separately the action of the different ingredients composing Bordeaux bouillie on the alga *Spirogyra longata*. Sulphate of lime had no action. Calcium hydrate is absorbed, beginning with a strength 1 in 3750 and then acts in an injurious manner. Cupric hydrate is not soluble enough in water to cede to it an amount of copper capable of preventing the growth of the alga. On the other hand, the contact of cupric hydrate with the alga kills it, owing to evident and visible absorption of copper. The chlorophyll bands are torn, the plasma contracted, and the colour of the contents browned. Rumm explains this fact by the secretions of the alga dissolving the cupric hydrate, and the soluble derivatives absorbed by it of a certain strength kill it. He observed, however, that this action was more dilatory the more lime the Bordeaux bouillie contained. In presence of a large excess of lime the action became *nil*. The Bordeaux bouillie acts therefore on algæ containing chlorophyll as on other green plants.

**Action of Bordeaux Bouillie on Fungi.**—Cupric hydrate is not soluble enough in water to prevent the germination of the spores most sensitive to copper salts, even after prolonged treatment with them. To understand the action of Bordeaux bouillie, it is, however, necessary to admit that there is a partial solution of oxide in the water deposited on the plant owing to the contact of this oxide with the active organs of the latter. Clark, in examining the poisonous capacity of the most diverse derivatives of copper on fungi cultivated in a nutritive liquid, beet extract, observed that this liquid dissolved cupric hydrate. Examining afterwards other substances of vegetable origin, he found they had the same property. This led him to believe that hydrated oxide of copper insoluble in water is much less so in presence of special organic substances. Swingle had already shown that the secretions of certain fungi dissolve cupric hydrate. Clark found afterwards that extracts of *Psaliote campestris*, as well as infusions of different parasitic fungi, dissolve this oxide of copper in sufficient quantity to prevent the germination of their spores. The nature even of the fungi would thus contribute to dissolve the amount of cupric hydrate required to prevent the development of the spores.

The rapidity with which the spores are destroyed depends on the thickness of the exospore. On the other hand, Sorauer believes that the spore is never killed by the presence of cupric hydrate in the drop of water in the midst of which it is developed, but that, on the contrary, this copper derivative, by weakening it, prevents the germination tube from penetrating into the nurse plant. Hence, spraying with Bordeaux bouillie on a plant invaded by a fungus is never capable of destroying the mycelium of this fungus developed in the interior of the plant. It cannot even prevent the latter from fructifying normally, and spreading around it spores to propagate the disease. The sole object of spraying with Bordeaux bouillie is to prevent the penetration of these spores into healthy unattacked plants or their organs. When spraying is done in the right conditions, the Bordeaux bouillie covers all the vulnerable surface of the plant with a layer of cupric hydrate. This layer forms a fixed and adherent reserve of a poison of which an infinitesimal quantity dissolved by the juices of the leaf stops the normal evolution of the spore fallen on a drop of dew. At the same time the very small quantities which penetrate into the plant impart to it greater vigour which enables it to become to a certain extent immune to the disease.

**Use of Bordeaux Bouillie.**—*History.*—It was found by a chance observation that a mixture of lime and copper might be useful in the struggle against cryptogamic diseases. To prevent marauders from gathering the ripe grapes on vines along the roads it was customary, long before the appearance of mildew, in the different communes of Burgundy to spray the grapes with milk of lime, to which was added a little blue vitriol to blue it. They treated five to six stocks in the border in this way. As far back as 1882 it was found that these borders were less subject to mildew than the rest of the vineyard, and when the disease assumed extensive and intensive proportions, as was the case in 1884, round about St. Julian, this border bespattered by milk of lime, blued by blue vitriol, appeared quite different from the rest by the verdure of the leaves, and by the perfect health of the grapes. Owing to experiments made by Millardet and Jouet, it was found that this fortunate action was to be attributed to the copper and not to its lime. This empirical remedy was thus recommended to combat mildew, under the name of Bordeaux bouillie. In the beginning the Bordeaux bouillie was much stronger than now. It consisted of 15 per cent. of lime and 8 per cent. of blue vitriol. This bouillie was spread on the vine by means of small heather brooms, for its consistency did not allow the use of a spraying machine. From year to year the dose of blue vitriol was diminished, and the lime, an excess of which was found useless, was reduced to the dose strictly necessary. In 1887 Bordeaux bouillie consisted of 3 per cent. of blue vitriol and 1 per cent. of quicklime. Millardet and Gayon had already experimented at this time with weaker bouillies, with 2 per cent., and even 1 per cent. of blue vitriol. As these bouillies produced the same effect, they regarded them as efficient and recommended several sprayings with a 1 per cent. bouillie in preference to a single spraying with a 3 per cent. bouillie of blue vitriol. These results were published in 1888, and spread the formula of the new bouillie over the whole world, where it was adopted as the normal bouillie. Owing to a great increase in the price of blue vitriol it was tried to reduce the amount of blue vitriol entering into the bouillie. Guocdenovic has shown that a 0·5 per cent. bouillie suffices in all cases. Zweifler extended his experiments from 2 per cent. to 0·1 per cent. bouillie, and concluded that 0·5 per cent. of blue vitriol was sufficient—an efficient bouillie against mildew. These proportions are used on the large scale and with great success in Italy and the Tyrol. Used at

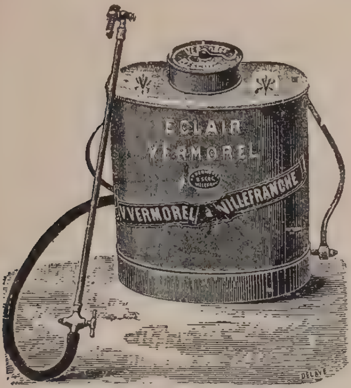

FIG. 8.—Eclair Sprayer.

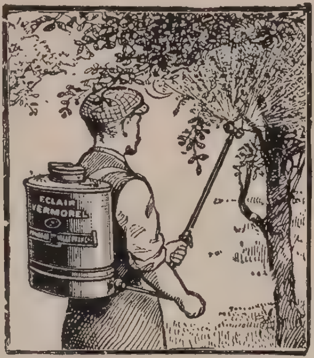

FIG. 9.—The "Eclair" Sprayer for Fruit Trees.

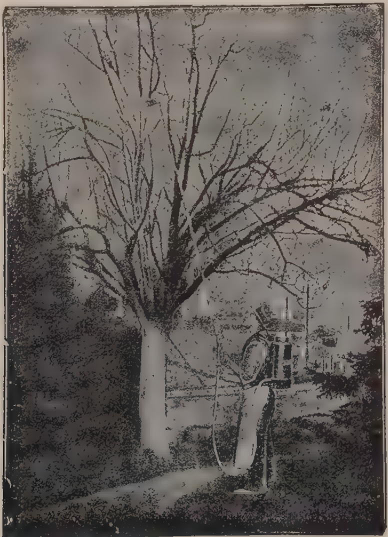

FIG. 10.—Spraying Tall Trees with Bamboo Extender.

first exclusively against mildew it has been found that Bordeaux bouillie is perfectly capable of combating a great number of other diseases.

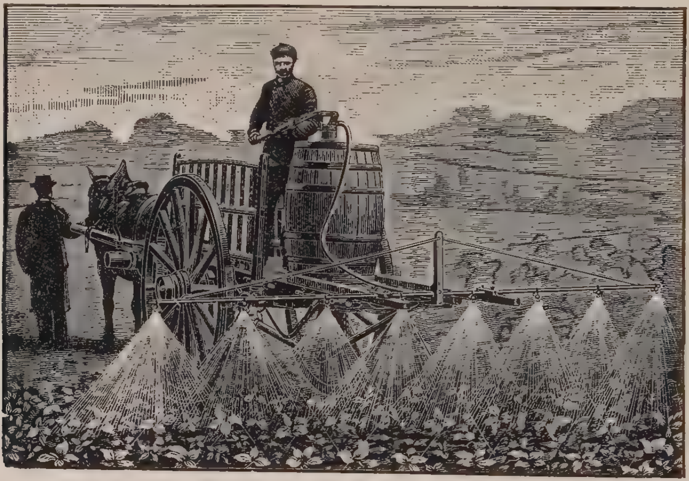

Fig. 11.—Barrel Pump for Field Work.

**Practical Spraying.**—The less cupric hydrate in the bouillie the greater must be the number of sprayings. Repeated spraying against plant diseases is in general favourable, because only the organs of the plant reached are rendered invulnerable, so far as wind and rain have not removed the preservative layer of copper oxide. To preserve a plant for the whole year from disease, the growth of the spores of parasitic fungi must be stopped. As there is a continual growth of

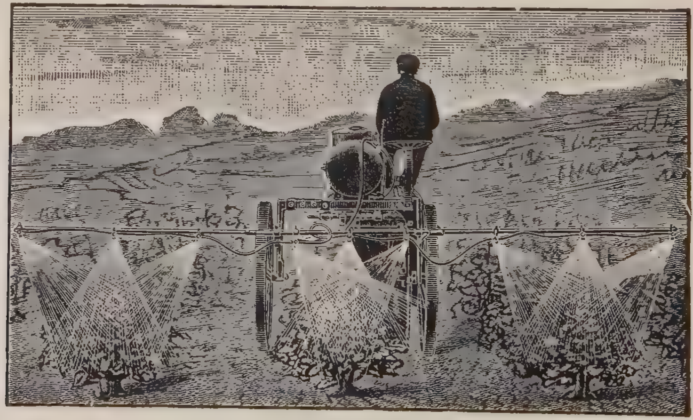

Fig. 12.—Eclair Sprayer Supra.

new leaves uncovered by Bordeaux bouillie, several sprayings must be applied preferably during fructification of the fungi, and especially during the germination of their spores. To prevent plant disease by Bordeaux bouillie it is necessary—

1. That the bouillie be made conscientiously according to the preceding rules. Bordeaux bouillie is mostly used neutral. However, numerous experiments have shown that in certain special cases it is better to use bouillies containing an excess of lime. Certain fruit trees, sensitive to neutral Bordeaux bouillie as much as to pure blue vitriol, are so no longer when there is excess of lime. Against the cryptogamic

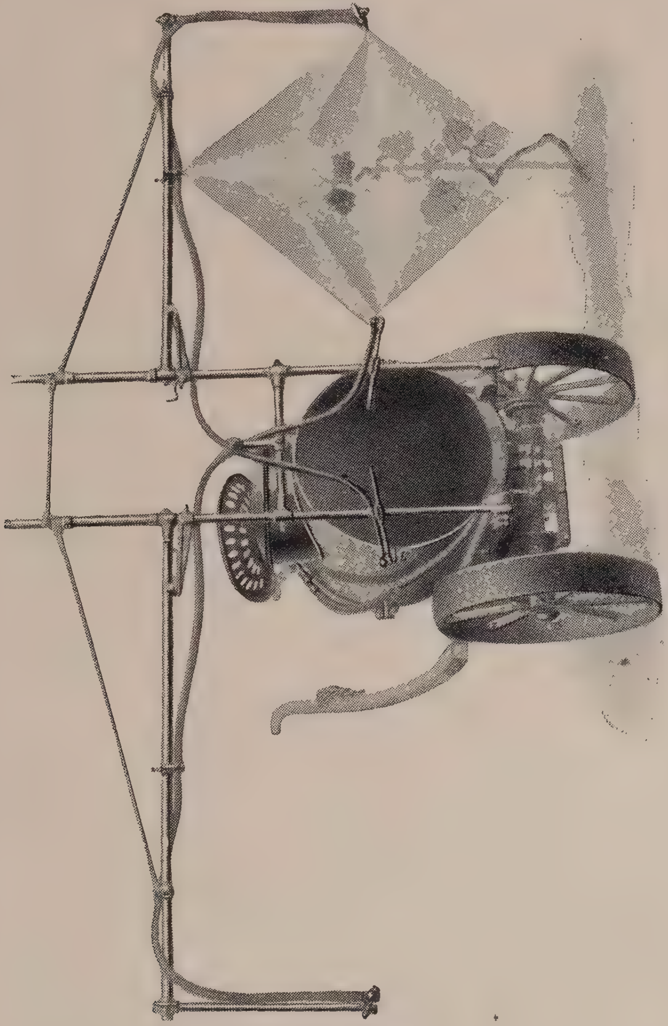

FIG. 13.—Vermorel's Spraying Machine, "Le Priam."

diseases of the apple and peach trees, it is well to use 0·5 per cent. of blue vitriol and 4 per cent. of quicklime.

2. That the evolution of the disease to be fought against be perfectly known, so as to be able to treat it at the moment of the dissemination of the disease, and prevent in time its establishment in the plant; a slight delay in the use of the remedy may lead to complete failure, for it is asserted by Prillieux that spraying after the penetration of the spores of the fungi into the interior of the tissue of the plant in no way prevents its normal evolution and fructification. If a great number of fungi may thus be combated by a neutral well-made bouillie, with 0·5—1·0 per cent. of blue vitriol, the application of the remedy must vary with the method of propagation and evolution of the fungus. If these rules are observed Bordeaux bouillie gives perfect results in all cases quoted farther on. Hence there is given in the footnotes a brief sketch of the evolution and manner of life of the chief parasitic fungi, so that the amateur little versed in these questions may find both the remedy and the best time to use it.

**Use against Mosses and Lichens.**—Although cupric hydrate has not the solubility of blue vitriol its regular use on the trunks of trees helps to lessen these parasites and eventually cause them to disappear. For this purpose a 3 per cent. Bordeaux bouillie applied on the trunks after cleaning with a scraper is recommended.

**Use against Bacterian Diseases of Plants.**—Amongst the ever-increasing number of plant diseases attributable to bacteria some may be combated with Bordeaux bouillie.

*Potato Scab.*—Bolley, who discovered the cause of the scab, found that disinfection of the tubers with 2 per cent. Bordeaux bouillie was capable of preventing the growth of this disease. He got the following result :—

TABLE XXXVII.—*Showing Effect of 2 per cent. Bordeaux Bouillie in Preventing Potato Scab.*

| Tubers. | Duration of steep. | Sound tubers per cent. |
|---|---|---|
| Untreated | — | 1 |
| Treated | ½ hour | 57 |
| ,, | 3 hours | 53 |

Longer steeping of the seed in Bordeaux bouillie does not injure the seed if it has not sprouted.

*Bacterian Disease of the Wild Quince-tree.*—This disease, known in America, has been successfully treated with Bordeaux bouillie.

**Use against Parasitic Fungi.**—*Peronosporæ.*—The eighty known species, some more formidable than others, have the same evolution and the same method of dissemination. They may be treated with Bordeaux bouillie.

*Phytophthora infestans*, de By. (potato disease).—To avoid the *Phytophthora* sound tubers which do not bring the first germs into the field must be planted in the first instance, and secondly sprayed on the stems to prevent the propagation of the disease by plants accidentally attacked.

**Treating the Tubers.**—Beyond scrupulous sorting disinfection may be of great service. Of all the treatments recommended, that of Bordeaux bouillie is the most energetic and the most certain. The tubers are steeped in a 2 per cent. Bordeaux bouillie; 10 gallons of bouillie suffice for 100 lb. of tubers. The duration of the steep is twenty-four hours, after which the tubers are steeped for twenty-four hours in pure water, then they are dried in the open air. The treatment should be carried out five to six weeks before planting. The disinfection has no objectionable effect on the germinative capacity of the tuber if the process be conducted as recommended by Frank. Godefroy found no alteration even after several days' steeping in the bouillie. Frank and Kruger found the treatment, on the contrary, favourable to the future evolution of the potato; it springs up quicker and yields a more vigorous plant and also a greater number of tubers in the ratio of 3 to 2. The good effects of the bouillie on the germinative capacity are not felt, except on condition that the tuber has no forward sprouts at the time of treatment, for the bouillie is very injurious to them. That is the reason why it is essential to disinfect potatoes some time before planting them, when they have not yet sprouted.

**Treatment of the Stems.**—So long as treatment by the Bordeaux bouillie was limited to the aerial part of the plant the results were not always favourable, especially as regards the yield in tubers, and opinions as to the efficiency of the treatment were divided. In fact it will be seen that where the *Phytophthora* has deeply invaded the tissue of the tubers a treatment of the stems with Bordeaux bouillie can prevent the evolution underground of the disease, and that failure is inevitable in such conditions. If all underground evolution is, on the other hand, prevented by a rational treatment of the seed potatoes, the effects of the aerial treatment will not fail to give satisfaction. It is not, therefore, surprising that certain experimenters have obtained, in some cases, a considerably diminished yield. Lieber found 20 per

TABLE XXXVIII. -*Showing Effect of Bordeaux Bouillie of Various Strengths on Weight and Starch Content of Potato Crop and per cent. of Diseased Potatoes.*

| Diseased plants. | Bordeaux bouillie strength, per cent. | Weight of crop per acre in tons metric. | Starch, per cent. | Diseased tubers, per cent. |
|---|---|---|---|---|
| Untreated | — | 10·28 | 19·1 | 6 |
| Treated | 6 | 11·2 | 18·0 | 2·8 |
| Untreated | — | 10·48 | 19·6 | 5·2 |
| Treated | 8 | 8·52 | 18·1 | 3 |
| Untreated | — | 10·4 | 19 | 4·5 |
| Two treatments | One 4, other 6 | 8·84 | 19·4 | 2 |
| Untreated | — | 9·9 | 18·01<br>(3928 lb.) | 15·5 |
| Treated | 2 | 9·96 | 19·28<br>(4405) | 1·5 |

cent. and Brunner 47·5 per cent., and that this treatment did not become general so rapidly as that for the mildew of the vine. However, successive experiments showed that a scientific application of Bordeaux bouillie killed the *Phytophthora* without injuring the plant. The diminution in the number of tubers, and in the starch which they contain, seems due to the poisoning of the leaves by imperfect bouillie, inducing a degeneration of the leaves, which renders them less fit for assimilation. The bouillies used at first contained too much copper and caused burns. Sempotovsky threw light on this point by showing that the weaker the bouillie the more active it is.

The number of sprayings in the year thus has a great effect on the efficiency of the treatment. Thienpont showed that the effects obtained by several sprayings are always superior to those obtained by a single spraying. Laplæ, in this connexion, got the following results :—

TABLE XXXIX.—*Showing Beneficial Effect of Repeated Spraying with Copper Bouillies on Potatoes.*

| | | | |
|---|---|---|---|
| Diseased plants untreated | | 10·44 | metric tons per acre. |
| ,, ,, | 1 spraying | 10·88 | ,, ,, ,, |
| ,, ,, | 2 sprayings | 11·94 | ,, ,, ,, |
| ,, ,, | 3 sprayings | 12·88 | ,, ,, ,, |

As to the weight of the crop, a great number of trials have proven the efficiency of the Bordeaux bouillie. Prillieux obtained with nine plants :—

TABLE XL.—*Showing the Effect of Bordeaux Bouillie on the Potato Disease.*

| Diseased plants. | Number of tubers. | Diseased tubers. |
|---|---|---|
| Treated | 115 | 9 |
| Untreated | 80 | 26 |

Steglich tried this treatment on six different species, planted in plots of 50 square metres, and in all cases obtained yields of from 10—80 per cent. higher than that of the untreated plot. The treatment consisted in three sprayings: on 12 June, 17 July, and 15 August. Andra, working on a field of 0·428 hectare, about 1·06 acres, obtained with one spraying :—

TABLE XLI.—*Showing the Effect of One Spraying of Bordeaux Bouillie on the Weight of the Crop of Magnum Bonum Potatoes.*

| Species. | Plants. | Tubers, lb. |
|---|---|---|
| Magnum bonum | Untreated | 7,750 |
| ,, ,, | Treated | 10,100 |

The cost of the treatment came to 3*s*. per acre, and the net profit to 57*s*. per acre. Mark, who experimented on fifty varieties, got an increased weight of crop of from 30—50 per cent. Stroebel found a higher yield of 48·7 per cent, and only 0·28 per cent. of diseased tubers, against 5·8—23·3 per cent. in the untreated field. Honeyball found a greater yield of 7—30 per cent. Finally in America and Switzerland the same effects have been realized, and this treatment is applied on the large scale in these countries as well as in France, in the whole valley of the Garonne, where it gives full satisfaction. Doubts as to the efficiency of the treatment of the *Phytophthora* by the Bordeaux bouillie are now no longer permissible; too many experiments show that applied at the moment of the evolution of the disease, it completely prevents it from spreading, thus preserving the crop so greatly compromised when the disease spreads normally. It is recommended not to apply the first spraying except at the moment when the first spots of the disease appear on the leaves. But it is better to make a first preventive spraying. The number of sprayings to be practised during the year is only regulated by the prevailing weather. If the year be moist and warm, conditions essentially favourable to its evolution and to very rapid spreading of the disease, it will be well to make several sprayings, only eight to fifteen days apart. During dry periods spraying is useless, and in the case of a very dry year, during which the disease does not assume a disquieting extension, a single preventive spraying may be regarded as sufficient. Scientists do not agree as to whether spraying is beneficial when the disease is not to be feared. Sorauer, an advocate of spraying at the time of the appearance of the diseases, has shown that if the infected fields, treated in time, yield a much greater number of tubers than untreated fields, it is no longer so when a field which is neither threatened nor invaded by the disease is treated. Sorauer experimented on perfectly sound tubers, which gave, before the appearance of the disease, a crop absolutely exempt from diseased tubers, whilst these same plants yielded, after the evolution of the disease, 59·4 per cent. of diseased tubers. These experimental fields gave before and after treatment :—[1]

TABLE XLII.—*Sound Plants, Showing Number, Weight, and Size of Large and Small Potatoes before the Appearance of Disease.*

| Plants. | Large tubers. | | Small tubers. | |
|---|---|---|---|---|
| | Number. | Weight. | Number. | Weight. |
| Treated | 28 | 843 | 102 | 752 |
| Untreated | 38 | 1337 | 43 | 423 |

TABLE XLIII.—*Diseased Plants, Showing Number, Weight, and Size of Large and Small Potatoes after the Appearance of the Disease.*

| Plants. | Large tubers. | | Small tubers. | |
|---|---|---|---|---|
| | Number. | Weight. | Number. | Weight. |
| Treated | 45 | 1450·8 | 92 | 810·8 |
| Untreated | 33 | 1191 | 91 | 1191 |

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[1] Part of the potatoes of both plots were lifted before the disease appeared.

According to this table the untreated sound plants, *i.e.* the tubers of which were lifted before the disease appeared, gave a greater yield of tubers than those treated with Bordeaux bouillie. Sorauer explains this fact by a certain degeneration of the leaf, very characteristic, which is the result of treatment with cupric compounds. This degeneration is espcially pronounced when the bouillie used still contains unconverted blue vitriol, or when sprayings are made with a soluble salt such as acetate of copper. Sturgis got the following results with various copper preparations :

TABLE XLIV.—*Showing the Effect of Various Copper Preparations on the Bulk of the Potato Crop, and the Number of Diseased Potatoes.*

| Per cent. | | Bushels per acre. | Diseased tubers. |
|---|---|---|---|
| 1 | Blue vitriol | 286 | 0 |
| 1 | Lime | | |
| 0·1 | Emerald green | | |
| 0·5 | Blue vitriol | 269·5 | 0 |
| 0·1 | Lime | | |
| 0·15 | Copper acetate | 181·5 | 0 |
| 0·06 | Emerald green | | |
| 0·125 | Blue vitriol | 156 | 0 |
| 0·250 | Ammonium carbonate | | |

Sorauer advises not to spray early varieties, generally lifted before the disease develops in a threatening manner, for the treatment would not only be useless, but might lower the weight of the crop. Frank and Kruger are of a contrary opinion. They have shown that sound potatoes sprayed several times in the year have a more vigorous growth and a greater vitality than untreated plants. The copper treatment increases the crop of tubers (Gutzeit), even in dry seasons, when the disease is not to be feared, in the ratio of 100 to 163, and according to Leydhecken by 2 per cent. These observers reckon that the Bordeaux bouillie treatment is imperative in all cases, because it is always followed by an increased crop, whether the copper acts as a stimulant of the plant or whether it prevents the invasion of parasites, so numerous as to lower the assimilative capacity of the leaves by the greater or less damage which they produce in them. The disinfection of seed potatoes, and the treatment of the stems with Bordeaux bouillie, always protect the cultivator from those sudden outbursts of potato disease, and enables him to produce uniformly good crops. The *Phytophthora* does not attack potatoes alone, but other plants of the *Solaneæ* family, such as the tomato (*Licopersicum*). What has been said as regards the potato applies to this plant. Pellegrini successfully treated this disease with a bouillie of 3 per cent. blue vitriol and 1 per cent. of lime. By three sprayings on tomatoes already attacked, the first on 15 June, the second on 2 July, and the third on 15 July, Howell succeeded in getting 4 per cent. of diseased fruit on the treated plot, against 60 per cent. on the untreated plot.

*Phytopthora phaseoli*, Thaxter (Lima bean mildew).—This *Phytophthora* devastates the haricot (*Phaseolus lunatus*) fields of America. Sturgis treated this fungi successfully with Bordeaux bouillie.

*Peronospora viticola*, de By. (mildew of the vine).—If the water favourable to the development of the spore contains the most minimum amount of copper the conidia does not hatch, or if it hatches, the germination tube cannot penetrate into the leaf. The object of the Bordeaux bouillie treatment is thus to prevent the conidia from forming new hotbeds of infection by stopping its evolution. It will be seen that the amount of copper to be deposited on the leaves need not be great to produce this effect, and that a weak Bordeaux bouillie may have the same action as the concentrated bouillie formerly used. But it is not possible to go below certain limits. Trials made with 0·5 per cent., and even 0·1 per cent., have shown that, if the action of the copper is still perceptible, with 0·1 of blue vitriol in the Bordeaux bouillie, that strength can no longer entirely prevent the hatching of the disease. After the use of a 0·5 per cent. bouillie there may still remain some rare leaves attacked by mildew. The 1 per cent. bouillies, on the contrary, are always sufficient, and absolutely as efficient as the classical 2 per cent. bouillie. In most cases this 1 per cent. bouillie is used. The 0·5 per cent. bouillie is used when the treatments exceed five in a year. By seven treatments with a 0·5 per cent. bouillie, Galloway got 99 per cent. of sound grapes. It is, in fact, better to renew a thin copper deposit on the leaves and grapes often than to spread a thick layer two or three times a year; the organs are continually growing, and washed by the rains. The great point is to cover all the surface of the vine uniformly with Bordeaux bouillie by copious and careful spraying. The first treatment can only preserve the leaves touched; the vine continues to grow, fresh applications are required to preserve the organs developed between the intervals of spraying. The treatment is oftener, and at shorter intervals, the more intense the growth. In the South of France, the heat of summer often stops all growth of the vine at the same time as the extension of the disease. This stoppage coincides with the second, or frequently with the third, treatment. In Central France, on the other hand, where the heat is less intense, and the summers are more rainy, the vine grows without interruption the whole summer. There the number of treatments ought to be much greater to preserve all the new leaves as developed. It is necessary to protect the grapes in the same way to prevent "rots." These also must be covered early with a coating of cupric hydrate. If in hot countries three sprayings be sufficient, in temperate and moist years a fourth and fifth treatment is required. A sixth and seventh treatment is useful, especially when frequent rains remove part of the copper deposit. In a dry year the moisture of autumn renders a treatment necessary before the vintage. It is especially recommended for young plants particularly sensitive to mildew; this treatment enables them to retain their leaves longer and completely ripen their wood. In districts exposed to sea-winds, which are very favourable to this disease, as many as nine treatments are given. No general rule can be laid down as to the number of sprayings; it varies with the year and the district. The first treatment must be applied before the appearance of the disease, for, owing to its rapidity of spreading, it is sometimes too late when seen on the leaves. To be efficient it should be applied in the second fortnight of May. The second is applied towards the end of June, shortly after flowering, but it should never be done during flowering. Mildew being most formidable in June, it is thus the second spraying which should be applied with the greatest care, and most abundantly. These treatments must, according to the weather, be followed by one or several others, the last of which should be applied a fortnight before the vintage. The fear, formerly expressed, that this last vitriolizing might change the properties from a hygienic point of view, has been found unjustified. Numerous chemists and hygienists have shown that copper salts sprayed on grapes are conveyed in very small amount into the vat, and are almost totally eliminated in the lees after the fermentation of the wort. Whatever may be the strength of the Bordeaux bouillie the wine only contains traces of copper, which can have no injurious effect on the health of the consumer.

*Peronospora Schachtii* (mildew of the beet).—M. F. Just treated this disease by sprayings of 0·5 and 0·75 per cent. of Bordeaux bouillie with a slight excess of lime. Girard found, by treating beet-fields by a Bordeaux bouillie with 3 per cent. blue vitriol and 5 per cent. lime, if not a total increase in the weight of the crop, at least ½ per cent. more sugar. On 35 acres, of which 4 per cent of the beets were diseased, 5 hectolitres (110 gallons) of 3 per cent. bouillie gave the above good results.

*Peronospora gangliformis*,[1] de By. (lettuce disease).—Sulphur, formerly used by kitchen gardeners, having no action on this blight, the mycelium of which lives in the interior of the leaves, it has been tried to treat it with copper preparations. Young lettuce leaves are very delicate. They require as much care as vine leaves, and the bouillie must be prepared with great care. To be effective the treatment must be preventive. When the bed is prepared, either for sowing or transplanting, it is watered with a 4 per cent. solution of blue vitriol, or with a 4 per cent. bouillie so as to reach all the surface parts. The bed in contact with the plants is thus disinfected. During growth a very neutral bouillie, made with 0·5 to 1 per cent. of blue vitriol, is spread on the plants in the evening or in cloudy weather. The effects are not so categoric as those obtained in the treatment of mildew of the vine. The exceptionally favourable conditions to the development of the *Peronospora gangliformis* created by kitchen gardening, its rapid growth demanding several treatments close to one another, the fact that the conidia to not give rise to the formation of zoospores, generally ten times more sensitive to copper salts than the conidia themselves, are the causes of some failures.

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[1] PERONOSPORA GANGLIFORMIS (lettuce mildew).—The lettuce mildew does not attack lettuces alone but different other composite plants. It often attacks artichokes, chicories, and cinerarias. There are annually grown by market gardeners (French) about 2,000,000 lettuces, of which the *Peronospora gangliformis* sometimes destroys a third. It appears chiefly on the salads forced in beds to sell as early vegetables. The leaves are covered, especially below, with white efflorescences formed by the conidiophora. The conidia germinate very easily, without, however, forming zoospores like the *Peronospora viticola*, by issuing directly a germinative tube which penetrates the leaf and creates in the cells a new mycelium. The leaves invaded commence by yellowing, they then dry or rot. It is necessary never to throw them with the dung which will form the mould of the following crop, but to destroy all the diseased plants. To avoid invasion, it is well to select new soil into which to transplant the lettuce.

*Peronospora Viscine*, de By. (mildew of the pea and the bean). Treated by spraying as soon as the spots appear on the leaf.

*Peronospora arborescens*,[1] de By. (mildew of the poppy).—Treated by Bordeaux bouillie before the appearance of the disease.

*Peronospora Schleideni*,[2] Ung. (mildew of the onion).—Spraying with bouillie is effective.

To sum up, Bordeaux bouillie forms an excellent means for treating and preventing mildews. These diseases all have the same method of dissemination by summer spores which enables them to become deadly to crops in a comparatively short time, especially in a moist, warm season. They should be treated preventively by Bordeaux bouillie at the moment the first symptoms of the disease appear, or better still, before their appearance at the epochs propitious for the rapid spread of this fungus. Applied with care Bordeaux bouillie always gives a perceptible and useful result, paying liberally for the cost of the treatment. A single spraying cannot produce immunity for the whole year, and if it be desired to preserve the plants from all attacks this treatment should be applied judiciously each time that the weather is favourable to a deadly extension of this fungus.

*Plasmopara cubensis*, B. et C. (mildew of the *Cucurbitaceæ*).—This fungus attacks *Cucumus sativus*, *Melo cucurbita maxima*, *Citrullus vulgaris*.—It may be treated by Bordeaux bouillies repeated several times a year. Stewart produced by this treatment 102,000 vegetable marrows instead of 20,000 on an untreated plot of the same size.

*Ustilaginæ*.—After the fortunate results obtained by vitriolizing corn-seed by Kuhn's method, consisting in steeping in a solution of blue vitriol followed by washing in milk of lime, it was interesting to treat corn-seed with Bordeaux bouillie. Experiments in this direction show that the action of cupric hydrate is, so to speak, *nil*. That is not at all surprising seeing that the spores of the *Ustilaginæ* are much more resistant to copper compounds than the spores of the *Peronosporæ*. In treating the different mildews the object of spraying with Bordeaux bouillie is to prevent the spores from germinating and penetrating into the vulnerable organs. The Bordeaux bouillie cannot destroy the very resistant zoospores or dormant spores but only the extremely sensitive zoospores. Besides it cannot kill the winter spores of the *Ustilaginæ* which infect grain, and only in an indifferent manner hinders their germination; it cannot, therefore, prevent them from penetrating into the young plant which it does not protect. Hence Kellermann and Swingle declare after many trials that Bordeaux bouillie cannot replace blue vitriol in the disinfection of corn-seed.

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[1] PERONOSPORA ARBORESCENS (mildew of the poppy).—It attacks the leaves and the inflorescences and may cause great damage.

[2] PERONOSPORA SCHLEIDENI (mildew of the onion).—This mildew causes great damage to onion crops. In wet weather it may assume such an extension that the whole of the plant is invaded and all the onions perish rapidly. Like all *Peronospora* the mycelium lives in the interior of the leaves, and discharges conidiophora through the stomata. The stocks attacked by this parasite have leaves with yellow zones which wither; the plants become yellow and finally die.

Bedfort obtained the same negative result. After steeping oats-seed in Bordeaux bouillie made with 2 per cent. blue vitriol and 2 per cent. lime there were as many "rust" ears as sound ears, whilst seed from the same source disinfected the same day by 2 per cent. formaline produced no diseased ears. In the preventive treatment of *Ustilago Maydis*, Corda (rust of maize), Halsted found a diminution in the disease but not its total suppression. Bordeaux bouillie cannot, therefore, as recommended by Van Tubeuf, replace blue vitriol in the disinfection of corn-seed.

*Uredineæ* (rusts).—Bordeaux bouillie has been used with greater or less success to treat some species of rust. The object of spraying with the Bordeaux bouillie was to prevent the summer spores of the ecidium and uredo from germinating and spreading the disease. Bordeaux bouillie cannot be used practically to combat the more deadly rusts.

*Rusts of Cereals.*—Numerous trials by Galloway, Swingle, and Bartholomew, both with Bordeaux bouillie and cupric borate, cupric ferrocyanide or eau celeste, trials which consisted in practically spraying every ten days the whole plant, gave no satisfactory result. This check is attributed to—

1. The difficult adherence of the bouillie on the cereal grain. Even if sugar, gum, or glue be mixed with Bordeaux bouillie, the plant cannot be covered with a layer of cupric hydrate capable of preventing the germination of the spores to be found there.

2. The strength of the ordinary bouillies, 0·5—2 per cent., which is quite insufficient. To obtain an appreciable result very strong bouillies must be used, made with about 8 per cent. of blue vitriol. These might have an immunizing action on cereals, and prevent the disease, if the great expense and the practical difficulty did not remove this treatment from cultural methods. Galloway, Kellermann, and Cobb thus obtained, by spraying every ten to twenty days, from 28 October to 24 June, on winter wheat, fields free from rust. Swingle found that the proportion of plants attacked by rust is thus lowered from 84·2 to 18·3 per cent. It is useless to dwell upon the failure of Bordeaux bouillie as a disinfectant of corn-seed against rust germs; not only does it have no effect, but it is quite useless in treating a fungus, the method of evolution of which is so different from that of the black rust, and which has methods of propagation which can only diminish the effect of disinfection.

*Puccinia pruni*,[1] Pers. (rust of stone-fruit trees).—Pierce successfully treated this fungus by three sprayings with Bordeaux bouillie at a month's interval. The spraying was begun before flowering. Trees so treated preserve their green leaves.

*Puccinia compositarum*,[2] Schlechtend (mildew of the *Compositæ*).—It is successfully treated with Bordeaux bouillie.

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[1] Rust of Stone-fruit Trees. *Puccinia pruni.*—This rust attacks the plum, apricot, almond, and peach-trees. It is recognized by its cinnamon-brown tufts consisting of uredospores on the under surface of the leaves and the rapid alteration of the latter. The trees attacked lose their leaves prematurely.

[2] Rust of Compositæ. *Puccinia Tanaceti*, *Puccinia compositarum.*—This rust, injurious to *Compositæ*, especially to *Artemisia dracunculus*, *Absinthium et vulgare*, *Tanacetum vulgare*, to the growth of chrysanthemums, is characterized by small round, brown and black cushions which spot the leaves.

*Puccinia Tanaceti*, DC.—Successfully treated by Halsted.

*Puccinia ribis*,[1] *Aecidium grossulariæ* (mildew of the gooseberry).—Sorauer recommends preventive treatment by Bordeaux bouillie. Eriksson recommends removing the diseased leaves in the autumn, and to spray soil and plant copiously in the spring.

*Uromyces betæ*,[2] Kuhn (beet mildew).—Nijpels relates that three sprayings with Bordeaux bouillie at a month's interval, commencing in June, appreciably diminished this disease.

*Gymnosporangium Sabinæ*,[3] Wint. (mildew of the juniper), and *Rœstelia cancellata*, Rebent (pear leaf cluster cups).—Knowing the polymorphism of this uredinæ it has been recommended to overcome this disease by destroying all the juniper-trees on which the fungus exists in its telento and uredo forms, so as to prevent the evolution of the fungus. It is sometimes made to disappear in that way, but very often the disease appears on the pear-tree, when there are no junipers in the district. It is then necessary to resort to spraying with Bordeaux bouillie. The experiments of Wess and Delacroix have shown that this process is evidently, if not absolutely, efficient. The first spraying ought to be made before the unfolding of the leaf, the second before flowering, and the third at a month's interval.

*Peridermium pini*, Wall. (vesicular rust of pine bark).—In addition to the destruction of swallow-wort and groundsel, preventive sprayings with Bordeaux bouillie in May have given such good results that this method has been adopted by the Belgian Forestry Department to prevent this disease in pine plantations.

*Exoascus deformans*, Fuckel.—It has been suppressed by the use of Bordeaux bouillie. Benton, Taft, and others have examined the action of copper compounds on the leaf curl and described the good effects got by rational application of Bordeaux bouillie. It follows from their experiments that the Bordeaux bouillie is the more active the sooner it is applied. The first spraying should be done before flowering in March and April, when the buds begin to swell. At that time strong bouillie made with 3 per cent. of blue vitriol may be used; however, 1 per cent. bouillie would suffice (Murill). The second spraying is done after the fall of the flowers, with a bouillie made with 0·5 per cent. of blue vitriol. The third spraying, if necessary, should take place when the leaves have reached their normal size. The result of these operations is not always complete the first year, but the second or the third year the " cloque " will disappear if care has been taken of the trees in this way. The " cloque " will not again appear if one or two preventive sprayings are given every year. The beneficial action of Bordeaux bouillie is surprising. It is generally allowed that cupric sprayings can exert no destructive action on fungi, the mycelium of which grows in the interior of the tissues. The preventive use of bouillies in different diseases should have no other object than to preserve the tissues, by preventing the spores which are deposited thereon from producing the disease. It is otherwise in regard to the leaf curl, where the bouillie is used as a curative agent. We know so little as to the method of propagation of the " cloque " (the artificial infection of peach-trees by spores has never succeeded) that we cannot exactly define what is the rôle played in its suppression by spraying with Bordeaux bouillie. We believe, however, that in this case the copper compounds deposited on the peach-trees destroy the mycelium of the leaf curl. The peach behaves in a special way towards cupric compounds. It can dissolve insoluble cupric deposits on its organs in quantities poisonous to the fungi and itself. It follows that the effect of the Bordeaux bouillie on the health of the plant is identical with that produced by spraying with pure blue vitriol. In most cases the use of cupric bouillie, even that of weak Bordeaux bouillie, produces the partial or total fall of the leaf reached by the preparation. Those which do not fall are riddled with holes, or seriously attacked. Are we to admit that the mycelium, which almost crawls on the leaf, since it is lodged between the epidermis and the cuticle, and is very little protected by the tissues, undergoes the first poisonous action of the salts of copper absorbed by the leaves? Or must it be admitted that the action of the Bordeaux bouillie results solely from the fact that the mycelium localized in the leaves is necessarily suppressed at the same time as the disease by the fall of the leaves? In our opinion beneficial action of Bordeaux bouillie results from the two following facts: (1) destruction of the mycelium of the *Exoascus* lodged in the buds in the spring; (2) its suppression, by the fall of the infected leaves in which the disease is localized. The fall of the leaves, incidental to the treatment, has no deadly action on the evolution of the tree, and there is nothing at which to be alarmed. The copper absorbed by the plant stimulates it, and causes a more rapid and more intense growth, so that the tree in summer and in autumn would be more vigorous than untreated trees. We therefore possess in Bordeaux bouillie a curative remedy for the leaf curl of the peach, a remedy which may be of great service to gardeners. We insist, therefore, on this point, that the treatment to be complete should extend several years, and should enter into the common customs of the orchard. Not only the cryptogamic diseases of the peach will be suppressed, but the quite exceptional vigour of the trees treated will enable better crops to be secured than on untreated trees.

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[1] Rust of Gooseberries. *Puccinia ribis.*—The rust causes great damage by attacking gooseberry leaves and fruit.

[2] Rust of Beet. *Uromyces betæ.*—This rust is autoic, which means that the whole cycle of its evolution is gone through on the same plant. All the forms of fructification may therefore be formed on the beet. It attacks the beet in summer, and may, when it assumes a great development, damage the leaves, and cause a perceptible decrease in crop.

[3] Gymnosporangium Sabinæ (pear leaf cluster cups).—This uredina is heteroic; it has its spermogonia and aecidium forms on the pear-tree, its uredo and teleuto forms on the *Juniper Sabinus.* The disease appears on the pear-tree in the spring. It forms big yellow spots on the surface of the leaves, spots which are besprinkled with purple-red spots, the spermogonia. At the end of the year these spots form white excrescences on the lower surface of the leaves, a sort of irregular galls, which contain aecidio spores. When these spots are numerous the growth of the pear is greatly weakened, but the parasite becomes especially dangerous to the crop when it attacks the fruits.

*Exoascus pruni* (pockets of the plum).—Sturgis asserts that he obtained a radical cure of the disease by Bordeaux bouillie.

*Erysiphe communis*, Wallr. (mildew of the pea).—This mildew is successfully treated by sulphur. Nijpels asserts that one or more sprayings with Bordeaux bouillie likewise cures the disease.

*Uncinula americana*, How. (oidium of the vine).—The mycelium crawls on the surface of the leaf and there produces its organs of reproduction. It was possible that this fungus, protected less than any other by the tissues of the nurse plant, might be readily destroyed by copper salts. It was also hoped to be able to supplant the sulphurating used against this disease by replacing it by vitriolization. This process would have much simplified the dressings required against the cryptogamic diseases. Neither blue vitriol nor cupric hydrate have, however, any curative or preventive action on this fungus, and it vegetates quite as well on leaves covered with Bordeaux bouillie as on untreated leaves. The treatment for mildew being an absolute failure against oidium, it remains necessary to continue the sulphurating of the vines at the same time as the vitriolizing with Bordeaux bouillie. Up to 1902 it was thought preferable to separate the two treatments. It seemed in the beginning that there was no drawback in the fact that one of the operations was conducted before the other, and it was the sulphuring, as the oldest known, with which the vine-growers began; but in considering the mechanical phenomena which are produced in this case on the surface of the leaf, it will be understood why it is necessary to precede the first sulphuring by vitriolizing. If the first treatment be sulphuring, the sulphur deposited on the leaves mechanically fixes a large part of the bouillie, which will not adhere to the leaves, and forms large uncovered spaces. There is really neither complete sulphuring nor vitriolizing. If, on the other hand, we vitriolize first and sulphur as soon as the spray is dry, the adherence of the sulphur is increased, and the two remedies have their full action on the cryptogamic diseases which they should overcome. To simplify the work of the vine-grower it has been tried to unite these two treatments in a single one; say by mixing the sulphur with finely pulverized copper salt, or by mixing the sulphur in the cupric bouillie. In the beginning the use of these mixtures often gave negative or very incomplete results, so that they were condemned as unfit to cure or preserve the vine from oidium or mildew, because the copper salts by seizing the vapours of sulphur poisonous to the oidium converted them into copper sulphide, inert towards mildew. Guillon reported to the Academy of Sciences altogether satisfactory results obtained with sulphurated Bordeaux bouillie in the Charente. Without denying the reactions which may occur between copper derivatives and sulphur, Guillon has, however, observed that these are slow to occur, and that bouillies sulphurated immediately after their preparation may act simultaneously on the two diseases before the sulphur has acted on the cupric hydrate. To mix the sulphur in the bouillie it is neessary to moisten it suitably. For this purpose water or the bouillie must be allowed to fall, drop by drop, on the sulphur whilst stirring. It is, however, preferable to incorporate it in the milk of lime. By adding the sulphur gradually to the milk of lime a yellow, homogeneous paste is obtained, which is afterward run into the solution of blue vitriol. This operation of moistening sulphur is, moreover, now simplified by the use of the moistenable sulphurs of commerce, the composition of which is as follows :—

TABLE XLV.—*Showing Composition of Moistenable Sulphur.*

| | Lb. | Lb. |
|---|---|---|
| Sublimed sulphur | 70 | 85 |
| Carbonate of soda | 20 | 10 |
| Powdered rosin | 10 | 5 |

By adding, at the time of application in the vineyards, 2 lb. of the moistenable sulphurs to 1 lb. of blue vitriol in solution, there is obtained forthwith a sulphurated Burgundy bouillie. This bouillie, used as soon as made, possesses the double property of preventing oidium and mildew. The more freshly made the more it adheres. The amount of sulphur used in these sulphurated bouillies should not be more than 2 or 3 per cent. But these bouillies have one defect, the sulphur tends to deposit; on the other hand, they have the advantage of containing perfectly neutral sulphur, which can no longer burn the leaves. The sulphuric acid contained in the sulphur, and which is often the cause of these burnings, is, in fact, often neutralized in these bouillies by the lime or by the carbonate of soda. So the direct producers most sensitive to sulphur, which generally cannot be sufficiently protected against oidium, behave well towards sulphurated bouillies. The latter, by the readiness with which they lend themselves to the simultaneous treatment of different cryptogamic diseases, constitute a real progress. Their use enters more and more into current practice, the more so as the results obtained by Guillon are confirmed. Cucovitch pointed out, in fact, at the International Agricultural Congress held at Rome, in 1903, the very decisive results obtained against mildew and oidium with a bouillie of 1 per cent. of blue vitriol, 1 per cent. of lime, and 2 per cent. of sulphur. Prosper Gervais likewise submitted his vineyard of Causses to this treatment, and found four treatments of sulphurated bouillie act as well as four sulphurings and vitriolizings as ordinarily performed. The first treatment took place before flowering, when the twigs of the stem had reached 12 inches. The second was made after flowering, as soon as the fruit became apparent. The third in the first fortnight of July, and the fourth in the first fortnight of August. A single sulphuring, abundant and penetrating, was made at the time of flowering, by means of Vermorel's torpedo, against the dropping of fruit and accidents of fertilization. According to other experiments, it would appear that the mono- and poly-sulphides of copper also act on oidium and mildew, from which it would appear that the sulphurated bouillie must act in any case. It is, however, acknowledged that sulphurated bouillies containing no sulphur compounds of copper render the most regular service in the struggle against these two diseases. In spite of its notorious failure against oidium of the vine, Bordeaux bouillie is recommended to overcome the fungi of the same family as oidium. Thus Selby recommends Bordeaux bouillie to overcome :—

*Podosphæra oxyacanthæ*, DC., blight which invades the apple and the cherry tree in America, but which in Europe only produces the hawthorn blight.

*Sphærotheca Morsuvæ*, Berk et Courte (blight of the gooseberry), which invades the fruits of this shrub in North America to such an extent as to entirely destroy the crop.

*Sphærotheca pannosa*, Lev. (mildew of the rose-bush and peach-tree).—The reports of cures obtained by treatment with Bordeaux bouillie are numerous. Ritzema Bos, Nijpels, and Speschneff recommend this treatment to overcome this disease. Nijpels recommends Bordeaux bouillie to overcome :—

*Microsphæra grossulariæ*, Wallr. (mildew of the gooseberry).—However, Bordeaux bouillie will not act so efficiently and decisively as sulphur at a high temperature, and cannot be advantageously used to overcome blights.

*Hypomyces perniciosus*, Magnus (mole disease).—This disease causes considerable damage in mushroom beds. Constantin and Dufour submitted the spores of this injurious fungus to the action of Bordeaux bouillie and found that prolonged steeping in a 2 per cent. bouillie does them little harm, and it is only after three to seven days' steeping that the spores are killed.

*Nectria ditissima*, Tul. (canker of the pear, apple, and beech-trees); *Sphæropsis malorum*, Peck. (apple rot, pear rot, quince rot).—To prevent these diseases Selby and Paddock recommend to scrape the trunk of the trees, to clean the wounds, and to spray the whole tree with Bordeaux bouillie. This process has no action on already formed cankers. Only their deep excision, followed by coating the living wounds with a concentrated solution of green vitriol, acidulated by sulphuric acid, can suppress them and cure the tree.

*Polystigma rubrum*,[1] DC. (plum-leaf blister).—Sorauer and Nijpels recommend to prevent this disease by carefully burning the dried leaves and spraying preventively with Bordeaux bouillie on the young spring leaves, or on the branches before the opening of the buds.

*Guignardia Bidwelli*, Viala et Ravaz (black rot of grapes).—In 1887 trials were made at Ganges with blue vitriol. In spite of the negative results of these trials the experiments were resumed the following year at Aiguillon with Bordeaux bouillie on a certain number of black-rotted vines. After three sprayings, made before the end of July, the stocks treated only had 14—24 per cent. of diseased grapes, whilst the untreated vines which surrounded them had 95—99 per cent. Great publicity was given to these fortunate results, so as to enable vine-growers to take in time the necessary steps to prevent the extension of black rot around the hotbeds of infection. Experience shows that Bordeaux bouillie does not act on black rot as on mildew. The summer spores of black rot being much less sensitive to the action of cupric preparations than the zoospores of mildew, it is necessary to use stronger bouillies and spray more often. This fungus may develop, like mildew, with unheard-of rapidity, and cause irreparable damage in forty-eight hours. The time of treatment should thus be chosen with circumspection, and the number of sprayings subordinated to weather favourable to the evolution of the parasite in question. Whilst dry, cold weather may completely stop black rot, on the other hand, moist, warm weather gives it full scope. It is therefore at such a time that it is most advisable to spray, and continue to do so at very short intervals. If in most cases three sprayings suffice, seven to ten are required in moist seasons.

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[1] POLYSTIGMA RUBRUM (plum-leaf blister).—In the spring the leaves attacked by this fungus are covered on the two faces by red spots corresponding to small receptacles of spores formed on the mycelium which develops in the middle of the parenchyma. The dead leaves contain peritheca, which produce spores in February or March.

Dussuc advises the use of the following sprays :—

Table XLVI.—*Showing the Composition, Volume Per Acre, Time of Treatment, and Order of Sequence of Bordeaux Bouillies used in the Prevention of Black Rot of Grapes.*

| Order of treatments. | Gallons of solution per acre. | Strength per cent. of the solution. | | Time of treatment. |
|---|---|---|---|---|
| | | Blue vitriol. | Lime. | |
| First | 17·6 | 3 | 3 | May |
| Second | 26·4 | 4 | 3 | June |
| Third | 35·2 | 5 | 3 | July |
| Fourth | 44·0 | 6 | 3 | August |

Dussuc believes the above gradually increasing quantities, used at the different times of spraying, are indispensable, so as to cover the entire surface of all the green parts of the vine. One of the essential conditions of success rests, in fact, on the care taken to spare neither the upper nor under surface of the leaves. When the vines have tufts which prevent the uniform penetration of the liquid, they should be further treated with powders containing blue vitriol and sulphur. By alternating the spraying with Bordeaux bouillie and with powders, the results obtained leave nothing to be desired. In America, four to five sprayings are used, the first on 5 May, and the last in autumn. Trials on the large scale made in America by 250 vine-growers secured to them a profit of £7400 (Galloway). The 4—6 per cent. bouillies, used in the beginning, are now abandoned and replaced by 2—3 per cent. bouillies. In France four treatments are the rule, and should be applied at the following periods in most instances :—

Table XLVII.—*Showing Order, Time of Spraying, and Strength of Bouillies in Treatment of Black Rot of Grapes* (Couderc).

| Order of treatments. | Time of spraying. | Strength of bouillies, per cent. |
|---|---|---|
| First | First week of May | 2 Blue vitriol, 2 lime |
| Second | Second week of May | 2 Blue vitriol, 2 lime |
| Third | Last fortnight of June | 3 Blue vitriol, 2 lime |
| Fourth | Last fortnight of July | 3 Blue vitriol, 2 lime, 2 molasses |

These epochs have been fixed according to the periodical development of black rot. Prunet, who examined black rot very closely, points out the parallelism between the evolution of the parasite and that of the vine, and has based on this fact a rational course of treatment, here given in full. The first invasion especially attacks the leaves, which on the vine branches, the first shot forth, are included between the third and the eighth; the second attacks chiefly those included between the tenth and the eighteenth, and in addition the pedicles of the flower and grape stalks; the third attacks the fruit when they are the size of a big pea, and also the leaves above the eighteenth; finally, the last attacks the fruit when of almost normal size. With such data, we ought to operate according to the intensity of the disease.

I. In the most intense hotbeds of disease.
II. In spots attacked rather strongly.
III. In those attacked feebly, or to an average extent.

| | | | | | | |
|---|---|---|---|---|---|---|
| I. | 1st | sulphating | when | 5–7 | leaves on | first branches. |
| | 2nd | ,, | ,, | 7–9 | ,, | ,, |
| | 3rd | ,, | ,, | 10–13 | ,, | ,, |
| | 4th | ,, | ,, | 15–18 | ,, | ,, |
| | 5th | ,, | ,, | the grapes | show themselves. | |
| | 6th | ,, | ,, | ,, | are big as a large pea. | |
| | 7th | ,, | ,, | ,, | are almost full size. | |
| II. | 1st | ,, | ,, | 5–8 | leaves on | first branches. |
| | 2nd | ,, | ,, | 10–13 | ,, | ,, |
| | 3rd | ,, | ,, | 15–18 | ,, | ,, |
| | 4th | ,, | as soon as grapes appear. | | | |
| | 5th | ,, | when grapes are size of pea. | | | |
| III. | Does not differ from preceding except by suppressing second treatment. | | | | | |

Where vineyards have been treated as soon as the disease appears success is complete and the disease easily overcome. However, if the formidable fungus has been allowed to develop without any obstacle before treatment, the perithecæ which spread the disease are so numerous that very often ten treatments do not give a complete result. This is especially the case when by negligence the black-rotted grapes have been left on the stock. It is thus advisable to support the spring and summer treatments by energetic winter treatments and by precautions which complete these treatments. In spring and in summer the spotted leaves must be removed; if one is surprised by the disease remove the buds and young branches from the stock so that the stem may be better aerated, and that the axillary sprouts do not form a dangerous neighbourhood for the grapes. In winter the leaves and attacked grapes left on the stock must be burned, then the stocks must be treated as for anthracnose by concentrated and acidulated solutions of green vitriol, so as to destroy, if possible, all the perithecæ which the following year transmit the disease to the vine. The strong doses of blue vitriol which enter into the composition of the bouillie used to combat black rot render the struggle against this disease very onerous, and almost impossible in districts where low quality wine is produced at a low price. Numerous trials have, therefore, been made with weak bouillie. In America especially it has been tried to overcome black rot with the bouillies in use against mildew, and encouraging results have been obtained. Galloway submitted different vines to the different treatment summed up in the following table :—

TABLE XLVIII.—*Showing Results of Repeatedly Spraying Vines with Blue Vitriol Solutions of Various Strengths.*

| Composition of bouillie, per cent. | Number of sprayings. | Date of spraying. | Sound grapes, per cent. |
|---|---|---|---|
| 3·25 blue vitriol | 6 | 27 April, 13 May, 25 May, 9 June, 22 June, 7 July | 94 |
| 1·6 ,, | 6 | 27 April, 13 May, 25 May, 9 June, 22 June, 7 July | 93 |
| 3·25 ,, | 4 | 27 April, 13 May, 25 May, 9 June | 89 |
| 1·6 ,, | 4 | 27 April, 13 May, 25 May, 9 June | 90 |
| 3·25 ,, | 3 | 9 June, 22 June, 7 July | 22·5 |
| 1·6 ,, | 3 | 9 June, 23 June, 7 July | 13·5 |
| Untreated | — | — | 1·1 |

These experiments show plainly that the concentration of the bouillies is less important than the frequency of sprayings, and the choice of the time at which they are executed. Trials with 0·5 per cent. bouillies gave favourable results, and Ecluse recommends to overcome black rot by the classical treatment for mildew, provided the first May spraying be done with a bouillie of 6 per cent. of blue vitriol and 3 per cent. of lime. It is not impossible for weak bouillie to give good results, but it must not be forgotten that in many cases the struggle is difficult, and the treatment applied against mildew is impotent against black rot. We therefore believe that it is indispensable to follow the method so carefully studied by Prunet, consisting in the use of 2 per cent. bouillies, a method capable of entirely preventing black rot, and of which the efficiency against mildew is absolute.

*Coniothyrium diplodiella*, Sacc. (white rot, pale rot, livid rot).—Although the preventive or curative treatment against this disease gives imperfect results, none the less it is recommended by Viala and Sorauer. But its application is difficult, because to obtain a satisfactory result the preventive sprayings on the grape must be done immediately after the formation of the wounds on the grape stalks, so as to prevent the spores from penetrating into the wounds.

*Alternaria Solani*, Sor.; *Macrosporium Solani*, Ell. et Mart.—Bordeaux bouillie overcomes this disease, which is characterized by the appearance of isolated spots of a brown colour brighter than those produced by the *Phytophthora infestans*; the leaves turn yellow at the same time. The tubers are not directly attacked but the exhaustion of the organs of the plant may reduce the crop. The organs of fructification are conidiophores which issue in tufts through the dried epidermis of the leaves. The detached spores germinate easily and readily spread the disease. Galloway advises a bouillie of 1·5 per cent. blue vitriol and 1 per cent. of lime. The first spraying is done with care, before the spots appear on the plant, so that all the leafy surface is covered with cupric hydrate.

*Alternaria brassicæ f. nigrescens*, Peglion (scorching of the leaves of the melon).—The use of Bordeaux bouillie was advised by Peglion.

It gives good results. The first spraying should be given the moment the small spot appears on the leaves and young shoots, and the second fifteen to twenty days later. A better result is obtained by adding a little sugar or ammonium chloride to the bouillie. Smith recommends in this case 1 lb. of sugar or ½ lb. of ammonium chloride to 15 gallons of water.

*Sphærella fragaria*, Sacc. (spots of the leaf of the strawberry).—Garman advises to overcome this disease a Bordeaux bouillie with 3·25 per cent. of blue vitriol and 2 per cent. of lime, used to spray every fifteen days until it disappears. Weiss has shown that a 1 per cent. bouillie suffices when used as spray before flowering, and after gathering the fruit. This bouillie is very adherent on the strawberries so that it cannot be used during the formation of the fruit, which could not be sold.

*Cylindrosporium Padi*, Karst. (cherry and plum-leaf blight).—This disease which, in America, causes the leaves of plum-trees and pear-trees to fall, is effectively overcome by three sprayings with Bordeaux bouillie in July and August (Selby). According to Galloway and Pammel the Bordeaux bouillie is a specific remedy against this disease. The best is a bouillie of 1·25 per cent. of blue vitriol and 0·8 per cent. of lime. According to Fairchild and Sorauer the trees should be sprayed five times—the first before the opening of the leaves, the following with fifteen days' interval. It is essential that the bouillie cover the two faces of the leaves.

*Sphærella morifolia*, Passerini (*Cylindrosporium mori*, Berl.[1]) (mildew of the leaves of the mulberry).—Bordeaux bouillie 5 per cent. gives excellent results (Caruso).

*Septoria*.—Trials against these diseases show that Bordeaux bouillie, judiciously applied, is an excellent method for overcoming them, especially if the first spraying be applied preventively before the opening of the young leaves.

*Septoria tritici*,[2] Desm., and *Septoria graminum*,[2] Desm. (nielle des cereales).—Kruger steeped the spores of the pycnides for twenty to forty hours in a 2 per cent. Bordeaux bouillie and found that they did not germinate after this treatment. Galloway observed a diminution in this disease in treating grain against rust by cupric preparations.

*Septoria ribis* induces the premature fall of gooseberry leaves.

*Septoria rubi*, Wert., produces pale spots bordered with red on raspberry and blackberry leaves. This fungus may be overcome by spraying with Bordeaux bouillie, as also may *Septoria Lycopersici*,

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[1] Cylindrosporium mori (rust of the leaves of the mulberry).—The leaves of the mulberry have brown, pale, irregular spots, limited by the veins. On these spots pustules are to be seen, in which conidia form, by which this fungus multiplies all the year round. The disease does not cause great damage; but it renders the leaves unfit for feeding silk-worms.

[2] Septoria.—These are parasitic fungi of the leaves. They produce withered and discoloured spots on which there are formed, below the epidermis, pycnides, which have pierced through the mouth of a hole through which the spores escape. There are more than 500 species of *Septoria*, but the small spots which they produce on the leaves are, in general, without serious consequence. Septoria tritici, Septoria graminum.—In the spring the leaves of autumn wheat are covered with spots; this fungus exhausts the leaves which wither and die prematurely.

Speg. (spots of the tomato leaf), and *Septoria Petroselini*, Desm. (pale spots of the parsley).

*Septoria cerasina*, Peck. (spots of the leaf of the plum-tree, cherry-tree, apricot, and peach-tree in America).—With three sprayings there is a marked but incomplete effect. Spots of the leaf of the chrysanthemum in Italy by five to six sprayings, containing a little soap.

*Septoria nigerrima*, Fuckel, and *Septoria piricola*, Desm. (white spots bordered with brown on the pear-tree).—According to Sorauer this disease is overcome by several sprayings, the first of which is given before the opening of the buds. According to Weiss by a spraying before and after flowering. This treatment is better than by potassium sulphide.

*Gloeosporium ribis*,[1] Mont. and Desm. (currant leaf spot).—Weiss advises to overcome this disease preventively by two sprayings, the first before the opening of the buds, the second after flowering.

*Gloeosporium curvatum*, Oudem. (disease of the leaves of the gooseberry).—Sorauer recommends the preceding preventive treatment by Bordeaux bouillie.

*Gloeosporium Juglandis*,[2] Mont. (walnut leaf disease).—Injurious to young plantations, it is combated preventively by spraying with Bordeaux bouillie (Sorauer).

*Gloeosporium venetum*,[3] Speg. (raspberry spot, in America).—Selby and Green recommend preventive treatment with Bordeaux bouillie.

*Gloeosporium frutigenum*, Berk. (bitter rot of the apple).—Garman and Stinson overcome this disease by four sprayings, the first before the fall of the petals, and the three others at fifteen days' interval.

*Gloeosporium phomoides*, Sacc. (anthracnosis of tomato, in America).—Halsted advises spraying with Bordeaux bouillie.

*Gloeosporium macropus*, Sacc. (orchid disease, especially the varieties Laelia and Cattleya).—Mangin advises a 2 per cent. Bordeaux bouillie.

Amongst the great number of *Phyllosticta*, Pers., which are characterized by the small round spots which they form on their nurse plants, only the following have been tried with Bordeaux bouillie :—

*Phyllosticta sphæropsidea*, Ell. et Ev. (horse chestnut [*Æsculus Hippocastanum*] leaf disease).—Fairchild has used Bordeaux bouillie as a preventive with success.

*Phyllosticta pirina*, Sacc. (pear-tree leaf spots).—Weiss has overcome this disease with Bordeaux bouillie.

*Fusicladium pirinum*, Fuckel (pear scab); *Fusicladium dentriticum*, Fuckel (apple scab).—It is very important for orchards to prevent this disease. The knowledge of the evolution of these fungi enables them to be overcome preventively. It is above all necessary to prevent the transmission of the disease from one year to another by destroying the holed branches, the spotted leaves and fruit, on which are formed the winter spores which infest the young organs of the new vegetation in the spring. This wise precaution is far from sufficient. The whole tree must be disinfected chemically by covering all its parts with a concentrated solution of green vitriol, acidulated by sulphuric acid, say with a concentrated Bordeaux bouillie containing 4—5 per cent. of blue vitriol and as much lime. Ricaud was the first to treat fruit trees with Bordeaux bouillie. He advised treating the walls and the trellises against which the trees are nailed up in the same way. It is almost indispensable to spray the soil copiously around the tree in autumn and spring, so as to disinfect the surface layer of soil, on which numerous germs of cryptogamic disease always fall with the leaves. A soil containing 4 per cent. of Bordeaux bouillie in no way affects the germination of seeds which may be afterwards sown around the trees. There are no vexatious consequences to be feared. Winter treatment, however well done, does not exclude the different summer treatments required to prevent this disease entirely. Physiologists who have studied the question advise two spring sprayings with Bordeaux bouillie. Stinson by three sprayings, the first of which was at the end of April, the second in the middle of May, and the third in the beginning of June, got 95 per cent. of healthy apples and 5 per cent. of spotted ones, whilst 91 per cent. of the apples on the untreated trees were attacked. Maxwell found seven sprayings were required to cause the disease to disappear entirely.

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[1] Gloeosporium ribis (currant leaf spot).—The disease produces withered spots on the leaves and causes them to fall in midsummer. A number of small spots are produced on the upper surface of the leaves attacked.

[2] Gloeosporium Juglandis (disease of the leaves of the walnut).—Fungus, which produces on the leaves of the walnut large reddish-brown or greyish spots on which black pycnides are observed.

[3] Gloeosporium venetum (raspberry spot).—This fungus produces grey spots bordered with red on the stem and leaves of the raspberry. They so damage the plants that the fruits do not ripen.

TABLE XLIX.—*Showing the Effect of the Number of Sprayings with Bordeaux Bouillie on the Percentage of Diseased Pears.*

| | Spotted pears, per cent. |
|---|---|
| Trees sprayed twice yielded . . . | 3·17 |
| ,, ,, three times yielded . . | 3·57 |
| ,, ,, seven times yielded . . | 0·00 |

The bouillies recommended in the beginning by Ricaud were made from blue vitriol 2 per cent. and lime 3 per cent. But apples and pears, particularly those which were grafted on quince-trees, were too sensitive for these bouillies. The strength has been greatly reduced and equally satisfactory results got with 1 per cent. or even 0·5 per cent. Taft ascribes the corrosive action of these bouillies on the leaves of apple and pear trees to the excess of lime which they mostly contain; he therefore advises absolutely neutral bouillies. Muller found that whilst pure cupric hydrate produced symptoms of poisoning on the plant, a 4 per cent. milk of lime had no effect. He observed that bouillies containing little blue vitriol (say 0·5 per cent.) and much lime (4 per cent.) produced less burns than neutral bouillies, even of 0·5 per cent.

The object of multiple treatments is to cover not only the leaves and the young shoots with Bordeaux bouillie, but also the young fruits. The number of sprayings evidently depends on the weather, as in the treatment of the vine against mildew and black rot. If frequent rains wash the leaves and fruit, and favour by moisture the development of summer spores, sprayings should be more frequent than in warm, dry weather. The first treatment is before flowering, the second immediately after flowering, and the third when the fruit is the size of a pea. Many investigators have demonstrated the absolute efficiency of treatment with Bordeaux bouillie against the scab. Galloway, Fairchild, and Beach have more especially observed the physiological effect produced on the tree by spraying. The ravages of the *Fusicladium* render the fruit unmarketable. Like all leaf parasites they do damage to these organs of assimilation and injure the health of the tree. The life of the plants is concentrated, on the one hand, in the leaves, and on the other hand, in the roots. Between these organs there exists an admirable correlation when they are intact, but as soon as one of these cannot fulfil its physiological functions, the other suffers. If the leaves are killed by parasitic fungi the roots cannot do their part. The sap which ascends, however rich it may be, cannot nourish the plant if this sap is not elaborated by the leaves; respiration is affected, assimilation is defective, the alimentation of the different organs of the plant by the descending sap is inefficient; if the leaves fall or are entirely destroyed life ceases. It is therefore important to prevent all wounds on the leaf, to stimulate their development, and to keep them as long as possible in a state of health. That is realizable if the many sprayings with Bordeaux bouillie are included in the necessary and normal dressings of fruit trees, as in the orchards of Sweden and America. A tree regularly and systematically treated with Bordeaux bouillie keeps its leaves healthy. By its stimulating effects cupric hydrate prolongs the vitality of the leaves until late in the season, and the growth of the trees being thus prolonged, become more vigorous than those which have not undergone this treatment. The amount of copper required to produce this remarkable physiological effect is almost infinitesimal, and the bouillies used need not be prepared with more than 0·5 per cent. of blue vitriol. Fruit trees being very sensitive to pure blue vitriol, it is necessary that the Bordeaux bouillie be prepared with great care.

*Fusicladium cerasi*,[1] Sacc. (black spots of the cherry).—Sirodot recommends the treatment and precautions used against apple and pear spots.

*Entomosporium maculatum* (leaf scald of pear and quince tree); *Entomosporium Mespili*, Sacc., or *Morthiera Mespili*, Fuckel (spots of the leaf of the pear).—The fruit trees are treated as indicated for *Fusicladium*. Experiments show that by several sprayings annually the ravages of this fungus may be prevented. In the beginning a 3 per cent. bouillie of blue vitriol and 2 per cent. of lime was used; but it was found that weaker bouillies are capable of rendering the same service. Maxwell obtained the following results with a 2 per cent. bouillie :—

TABLE L.—*Showing the Effect of Repeated Spraying with a 2 Per cent. Bordeaux Bouillie on the Percentage of Diseased Pear-tree Leaves.*

| | Percentage of diseased leaves. |
|---|---|
| Untreated trees . . . . . . . . | 75·84 |
| Twice treated trees, 25 April, 9 May . . . . . | 3·17 |
| Three times treated trees, 14 April, 25 April, 9 May . . | 3·0 |
| Seven „ „ „ 14 April, 25 April, 9 May, 5 June, 25 June, 14 July, 5 August . | 0·00 |

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[1] FUSICLADIUM CERASI (black spots of the cherry).—This fungus attacks cherries, on which it produces small black-green velvety spots. When the fungus invades the young cherry, the latter dries up, and withers before ripening.

To prevent great damage two sprayings suffice; but the disease is not entirely stopped until after multiple treatments. Waite advises a single treatment at the right time, that is to say, when the leaves are two-thirds of their normal size. Fairchild lowered the strength of the bouillie to 1·2 per cent. of blue vitriol and as much lime, and obtained the same favourable result by repeated sprayings as with concentrated bouillie. Sorauer and Stoll also found excellent results from Bordeaux bouillie used before the opening of the leaves.

*Colletotrichum Lindemuthianum*,[1] Br. and C. (anthracnose of the haricot and scarlet runner).—Beach overcame this disease preventively before sowing by steeping the haricot beans in Bordeaux bouillie, and afterwards spraying the plant with a weak bouillie of 0·8 per cent. of blue vitriol and 0·5 per cent. of lime. The first spraying was done before flowering, and the succeeding ones at fifteen days' interval, avoiding, however, spraying on the flowers, as the fructification would be hindered by the bouillie.

*Colletotrichum oligochætum*,[2] Cav. (*Nuite* or anthracnose of the melon).—Sprayings with Bordeaux bouillie produce no effect if used curatively (Prillieux); on the other hand, by their preventive use Selby and Halsted obtained excellent results.

*Cercospora apii*,[3] Fr. (celery-leaf spots).—This disease causes much damage in America, and methods of defence against it have been studied in that country. Halsted advises Bordeaux bouillie, Duggar and Bailey Burgundy bouillie.

*Cercospora beticolæ*,[4] Sacc. (beet-leaf spots).—Halsted recommends spraying with Bordeaux bouillie.

*Cercospora reseda* [5] (mignonette-leaf spot).—Fairchild advises a preventive treatment, consisting of three sprayings with a bouillie of 3·25 per cent. of blue vitriol and 2 per cent. of lime.

*Cladosporium fulvum*,[6] Cooke (tomato-leaf rust).—Curative treatment by cupric preparations is inefficient. On the other hand, a preventive treatment removes the disease. The evolution of the disease is slow. Spraying must be done early on the absolutely healthy plant and fresh spraying done every week. The good effects of preventive treatment with Bordeaux bouillie are well established.

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[1] Colletotrichum Lindemuthianum (anthracnosis of the haricot).—Fungus which attacks the leaves, stems, and pods of the haricot; it corrodes them profoundly, producing gnawed spots. These spots, sinking deeper and deeper, may extend into the fruit as far as the endocarp of the pod, and reach the grains. On the surface of the spots there is formed a great number of pustules, produced by the cuticle, uplifted by a mass of conidia.

[2] Colletotrichum oligochætum (anthracnosis of the melon).—The anthracnosis of the melon is observed on different *Cucurbitaceæ*. The disease is characterized by badly defined, yellowish spots which go deep down, especially in the fruit. The fructifications of the fungus appear on the dead tissues. They are small fleshy-rose masses containing conidia.

[3] Cercospora apii (celery-leaf blight).—The celery as well as other *Umbelliferæ*, such as parsley and parsnip, are attacked by this fungus, especially during the hot part of the year. The leaves are coloured with fawn-yellow spots, and when the fructifications appear they are covered with a brown dust.

[4] Cercospora beticolæ (spots of the leaves of the beet).—This fungus is a very common parasite which lives on the leaves of the beet, but which causes no special damage.

[5] Cercospora reseda (mignonette disease).—This fungus forms pale spots on the leaves of mignonette, which afterwards are covered with brown tufts of conidiophores. It causes much damage in America.

[6] Cladosporium fulvum (tomato-leaf rust).—The cladosporium causes great damage to tomatoes, especially in greenhouses. The leaves of the stocks attacked etiolate, turn yellow on badly defined portions of the limb.

*Cladosporium cucumerinum*,[1] Ell. and Art.—Frank did not obtain favourable results with cupric preparations, because the spores of this fungus have a great resistance to copper salts. Selby, on the contrary, was quite successful.

*Cladosporium carpophilum*,[2] Thüm. (spots of the cherry, plum-scab).—Selby advises Bordeaux bouillie to overcome it like *Fusicladium.*

*Cladosporium oleaginum*,[3] Castagne (olive-leaf spots).—At the Agricultural Institute of Pisa 200 olive-trees were successfully treated against this disease with a 0·5 per cent. bouillie, used four times in July, then in September, October, and November. The olive-trees so treated preserved their leaves intact, whilst the untreated had suffered much from the parasite. Vennuccini advises two preventive treatments, the first with a 1 per cent. bouillie in winter, the second with a 0·5 per cent. bouillie in spring. Brizi confirms the good results got by this treatment.

*Heterosporium echinulatum*, Cooke (fairy ring of carnations).—Selby overcomes this disease by Bordeaux bouillie.

*Lophodermium pinastri*,[4] Chev. (pine-leaf cast, fall of the needles of the pine).—Bartet and Vuillemin found in Bordeaux bouillie an excellent method for preventing this disease. Their experiments gave very decisive results. Two treatments with Bordeaux bouillie on two- to three-year-old plants, the first beginning in June, when the needles are half formed, the second a month later, when they are fully developed, assured the complete immunity of the young plants, whilst 80 per cent. of the untreated succumbed to the disease. Beck and Osterheld tried this treatment on a larger scale, and as far back as 1889 this process entered into the forestry practice of Bavaria. Von Tubeuf likewise tested the efficiency of cupric preparations on an experimental field at Dahlem. His experiments show that Bordeaux bouillie produces more effect in August than in June or September, and that it was superior to other cupric preparations. Bordeaux bouillie cannot destroy the mycelium developed in the interior of the plant, but it protects the sound needles of a pine-tree already invaded by the disease. Young plants which still have the greater portion of the leaves may be preserved if the healthy leaves are protected by energetic spraying at the moment when the new shoots have reached two-thirds of their height. The first treatment should be given in June, the succeeding ones very carefully in July and August, for it is at that time that the invasion is the most intense, and that the leaves should be entirely protected by a layer of cupric hydrate.

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[1] Cladosporium cucumerinum (cucumber rot).—This fungus produces on cucumbers black-greenish spots and the rapid rotting of the fruit.

[2] Cladosporium carpophilum (plum-scab).—It causes damage in America. It attacks the young fruits, producing spots, on which the skin is replaced by a sheet of cork underneath which hollows are formed; [attacks plums, cherries, almonds.—Tr.].

[3] Cladosporium oleaginum (spots of the leaves of the olive-tree).—The smooth mycelium glides under the superficial layer of cuticle and becomes encrusted in the upper cell walls of the epidermis; it does not penetrate into the parenchyma of the leaf; in this connexion it has a certain analogy with exoascus.

[4] Lophodermium pinastri (pine-leaf cast).—This parasite commits great depredations, especially in nurseries of two to three years old. As early as the autumn of the first year the seedlings are invaded and the leaves are spotted with brown and become red. Spermogonia are formed; as these grow the leaves wither up completely.

*Sclerotinia cydoniæ*, Schell.—This disease invades quinces and mummifies them. It may be overcome by spraying the tree before the opening of the leaves.

*Monilia frutigena*, Pers. (brown-rot of kernel fruits).—To prevent this disease the mummified fruits, brown before the harvest, must be collected in winter and carefully destroyed, for, as shown by Galloway, brown rot can only be overcome with difficulty by Bordeaux bouillie and other anticryptogamic products. Chester, by six sprayings a year with a big bouillie, from 29 April to 2 July, found that the number of diseased fruit was lowered from 32 per cent. to 13 per cent.; but that the disease cannot be entirely prevented. Montemartini likewise found the bouillie inefficient. Schoyen advises against this disease spraying before the opening of the buds.

*Botrytis cinerea* (vine sclerotinia).—Bordeaux bouillie is generally regarded as inefficient against the mould of grapes in autumn. Sorauer and Beauverie believe that, above all, the air should be allowed to penetrate more easily around the fruits by partially stripping the leaves and in cutting the shoots around the grapes, and to spray afterwards.

**Use of Bordeaux Bouillie against Insects.**—Cupric hydrate, deposited uniformly on the green parts of a plant, protects these against the attacks of insects and their larvæ. Plants regularly treated by Bordeaux bouillie are less sought after than untreated plants. After eating leaves blued by a deposit of cupric hydrate insects and their larvæ are poisoned and die. The contact and the presence of copper are so disagreeable to them that they often quit the tree after treatment with copper hydrate. Thus the caterpillars of the *Hyponomeute* of the apple abandon the silky gauze which serves to them as a shelter, and let themselves fall on the ground after spraying with Bordeaux bouillie (Sonnino). The *Eriocampa adumbrata* (slug-worm or slimy caterpillar), the caterpillar of the *Liparis chrysorrhea*, L., that of the *Gastropacha neustria*[1] (the lackey or barred tree lackey moth), are killed, according to Goethe, by the absorption of the blued leaves. The *Leptinotarsa decemlineata* (Colorado beetle) may be overcome by Bordeaux bouillie. The trees sought after by the anthonome of the apple-tree may be protected by spraying with Bordeaux bouillie (Montillot). The vines treated regularly by Bordeaux bouillie are abandoned by the *Altise* and the *Pyralis* (d'Andoque de Sériège, Martini). In general injurious insects are seen to diminish greatly in gardens where the trees are treated with cupric bouillie. Debray advises spraying with 2 per cent. Bordeaux bouillie to destroy *Cassida*

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[1] BOMBYX NEUSTRIA (the lackey or barred tree lackey moth). –Moth of 30 millimetres from tip to tip; reddish, the upper wings are crossed by two whitish lines. It appears in July; the female lays regularly around a branch 400 eggs which form a bracelet.

*viridis*,[1] L. (Coleoptera injurious to artichokes) and the caterpillars of the *Pierides*, injurious to the crucifers, rapes, cabbages, turnips, etc. This preparation has also been used successfully against the gooseberry saw-fly, *Ptereneus ribesii*. It also diminishes the number of the *Eriophyes piri*, Pgst., which cause the "cloque" of the pear-tree, and destroys the insect injurious to melons and vegetable marrows, *Diabrotica vittata*, Fab. (Sirrine). Its action is less decisive against plant-lice and coccides. By suppressing the fruit-tree smut, which accompanies the invasions of the coccides of the olive-tree, orange-tree, rose laurel (Pastre), and vine (Targioni-Tozzetti), it removes the greatest infliction incidental to the parasiticism of insects. Bordeaux bouillie does not, however, suppress coccides. Bordeaux bouillie is regarded by Dr. Menudier, Mohr, and D'Angelo as sufficient to remove the phylloxera. D'Angelo has used this process in the island of Elba with full success. The treatment comprised two sprayings of the stock with a Bordeaux bouillie of 1·8 per cent. blue vitriol and 1 per cent. lime, and three sprayings with a 5 per cent. solution of blue vitriol containing sulphur. Bordeaux bouillie is not frequently used for the destruction of insects, because it is not so energetic in its action as poisonous substances. Bouillies with a Scheele's green or emerald green basis, which contain both copper and arsenic, are preferred. Bordeaux bouillie possesses, to a certain extent, the insecticidal properties of arsenical bouillies. It likewise acts on the stomach of the insects which absorb it. To intensify its action organic insecticides are added to it; thus Martini reports that 2 per cent. Bordeaux bouillie, to which 1·5 per cent. of rubinia or carbolated tobacco juice was added, instantaneously kills cochylis of the vine. After one of these sprayings there were only 5·61—7·87 per cent. of grapes with caterpillars, whilst after a single treatment with pure Bordeaux bouillie, there were still 24 per cent.

Against *Fidia viticida*, Walsh (grape root-worm), American growers are recommended to use a spray of 100 U.S. gallons of Bordeaux mixture (8 : 8 : 100) with either 3 lb. of dry or 6 lb. of paste lead arsenate for the control of both insect and fungus. The addition of 3 lb. of resin fish-oil soap is advisable to improve the spreading qualities of the spray.

**Colloidal Copper Hydroxide.**—Ordinary Bordeaux mixture, commonly used as a fungicide, has several defects, such as a lack of sticking and liability to scorching. To effect improvements, H. D. Hooker, U.S.A., has suggested the use of a colloidal copper compound. This was prepared by adding a 10 per cent. solution of caustic soda to a solution of copper sulphate, with constant stirring, any excess of soda being avoided. The precipitated hydrate was repeatedly washed with distilled water by sedimentation. When all the salts were removed, the copper hydrate, on shaking with water, gave a colloidal solution which foamed, and contained copper hydrate to the extent of 1 part in 1,000. It remained in suspension for several weeks. Preliminary tests have indicated that such colloidal copper hydrate in 1 in 5,000 concentration has excellent sticking properties, and is fungicidal to apple scab and blotch.

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[1] Cassida viridis, or the artichoke tortoise beetle, is found in May and June on artichokes. The antennæ are black, the dotted wing cases and other outer coverings green.

# CHAPTER XV

## EAU CELESTE—COPPER PHOSPHATE—COPPER BORATE—COPPER FERROCYANIDE

**Eau Celeste.—Preparation.**—By dissolving a copper salt in water and treating the solution with an excess of ammonia a pale celestial blue precipitate of copper hydrate forms, then an intense celestial blue solution. Eau celeste is an ammoniate of copper oxide dissolved in water. Audoynaud, who first advised this liquor to replace Bordeaux bouillie in the struggle against cryptogamic diseases, prepared eau celeste by dissolving 10 lb. of blue vitriol in 3 gallons of hot water, cooling the solution, then adding about 1½ gallons of commercial ammonia. The concentrated eau celeste thus obtained keeps indefinitely. When required for use it is diluted with 200 gallons of water. Bellot des Minières advised for the preparation of eau celeste another method of manufacture, that of Schweizer's cupro-ammoniacal liquor, which is endowed with the remarkable faculty of dissolving cellulose. This method is based on the property of ammonia of dissolving metallic copper in presence of air, producing cuprammonium hydrate. A funnel is filled with red copper turnings, and ammonia of 22° Bé. poured on the top. The ammonia is passed and repassed several times over the copper. The solution is not finished until after a great many passages. With 1 lb. of copper 15 gallons of anticryptogamic liquor is produced. Copper carbonate likewise dissolves in ammonia, and the blue solution so obtained dissolves cellulose, like Schweizer's liquor, whilst, on the contrary, the ammoniate of copper hydrate, prepared from the sulphate nitrate, or the phosphate of copper, is not endowed with this special property. The anticryptogamic liquor obtained by dissolving copper carbonate in ammonia is called *eau celeste modifiée*, or ammoniacal carbonate of copper bouillie. Its preparation is more simple than that of any other copper bouillie, for it suffices to weigh a certain quantity of commercial copper carbonate, stir it up with the necessary water, and add ammonia to complete solution. The same result is obtained by adding ammonia to Burgundy bouillie until it is converted into a deep limpid blue liquor. In America it is customary to dilute ammonia to 26° Bé. with seven to eight times its weight of water, and to add copper carbonate whilst stirring until a small amount remains insoluble—a proof that the liquor does not contain an excess of ammonia, a condition which is not attended to in the greatest number of instances. If it be desired to prepare modified eau celeste from blue vitriol, Mohr's process is followed: Dissolve 3 lb. of blue vitriol in hot water and add gradually, after cooling the solution, 1 lb. of soda ash, then

12 fl. oz. of ammonia of 24° Bé.; dilute the blue liquor to 100 gallons. The same liquor is obtained by adding sodium carbonate to ordinary eau celeste or in mixing a solution of 1 lb. of blue vitriol in 50 gallons of water, with 2 lb. of ammonium carbonate in 50 gallons of water. Liquors with an ammoniate of copper oxide basis thus vary greatly, both as to strength and method of manufacture. When they are prepared it must not be forgotten that dry carbonate of copper contains 51 per cent. of copper, whilst blue vitriol which crystallizes with 5 molecules of water, only contains 25 per cent. So that a bouillie may have the same copper content twice as much blue vitriol must be taken as copper carbonate. A Bordeaux bouillie said to be a 1 per cent. bouillie, that is, made with 1 lb. of blue vitriol to 10 gallons of water, ought to be compared in its cryptogamic action with a 1 per cent. ordinary eau celeste, and with a 0·5 per cent. modified eau celeste made from copper carbonate, these bouillies containing the same dose of metallic copper.

**Properties.**—Compared without bouillies, eaux celestes have the great advantage of being limpid solutions, containing neither precipitate nor deposit capable of choking the spraying machines, or of being deposited at the bottom of tanks or vessels. Eau celeste is more easily used than Bordeaux bouillie, the more so as it is made a long time beforehand in a concentrated condition and can be kept indefinitely in that state. Formerly, Bordeaux bouillie contained a large excess of lime, which rendered its application exceedingly difficult. Eau celeste had properties which had to be considered and which gave it a real advantage. At that already distant time 0·5 per cent. eau celeste ran much cheaper than 2—3 per cent. Bordeaux bouillie. Eau celeste could also be more uniformly distributed than thick bouillie. Finally, the adherence of the thin pellicle of copper hydrate, which is formed after the evaporation of the ammonia from the surface of the organs covered with liquor, is much more perfect than that left by Bordeaux bouillie, and resists, according to Rossel, rains of seven to eight hours' duration. All these advantages were of a nature greatly to encourage the use of eau celeste at a time when Bordeaux bouillie was not sufficiently studied. Now it is otherwise. Carefully prepared, Bordeaux bouillie does not now contain an excess of lime; it has no more than 0·5—1·0 per cent. of blue vitriol, and thus no longer has the great drawbacks of the original Bordeaux bouillie, so that all the comparative advantages of eau celeste have almost disappeared. The advocates of eau celeste, especially the ammoniaco-cupric liquor, and the modified eau celeste, assert that eau celeste of this special composition is more active than Bordeaux bouillie, because it dissolves cellulose, and would thus, by contact with the organs, disintegrate them and destroy them much quicker than ordinary cupric bouillies. This opinion is very much open to question. If it really were so, it would be easy to determine the superiority of modified eau celeste and any other analogous preparation endowed with the extraordinary properties of Schweizer's reagent of dissolving cellulose. In opposition to this enticing theory there must first be placed the results of the comparative trials made with cupric anticryptogamics not endowed with this property, such as Bordeaux bouillie and Burgundy bouillie.

They do not establish practically the sporicidal superiority of eau celeste. Millardet and Gayon obtained the following results :—

TABLE LI.—*Showing the Effect of Spraying Vines with Eau Celeste, on the Density of the Wort, the Weight of the Wort per Kilogramme of Grapes, the Sugar Content per Litre of the Wort, and the Weight of the Grapes.*

| Vines. | Method of treatment. | Density of wort. | Weight of wort per kilogramme of grapes in grammes. | Sugar per litre of wort. | Kilogrammes of grapes. |
|---|---|---|---|---|---|
| Marcin | Three times with ammoniate | 1·060 | 667·8 | 120 | 76 |
| ,, | Twice with Bordeaux bouillie | 1·070 | 719·6 | 178·5 | 120 |
| Malbec | Three times with ammoniate | 1·083 | 739 | 208 | 142 |
| ,, | Twice with Bordeaux bouillie | 1·088 | 755 | 213·5 | 148 |

Secondly, highly dilute solutions of these cupric compounds do not dissolve cellulose unless after long maceration, and moreover, thirdly, the organic matter of which the cells of fungi consists is not cellulose, but an analogous substance which has not the same reactions as cellulose. Even if it be admitted that the liquor of Bellot des Minières can dissolve spores in contact with the solution, the method of application is against these properties being exercised. Sprayings, in fact, spread a thin layer of this liquor on the surface of the leaves; the ammonia evaporates forthwith, and there remains on the leaves insoluble cupric hydrate, with no solvent action on cellulose. The solvent action of this liquor only lasts a very short time, which would enable it to act curatively at the moment it is projected on to the diseased organs. The application of these preparations in the full evolution of mildew has produced immediate curative effects, which would plead in favour of a special action of which Bordeaux bouillie and Burgundy bouillie are deprived, but it is known that blue vitriol solutions exercise to the same extent a curative action on this disease. Solutions of copper hydrate in ammonia or in other alkalies have quite peculiar properties. Thus Bellot des Minières' preparation of a certain strength, like *eau celeste modifiée*, dissolves cellulose, and a solution of 5 parts of blue vitriol in 100 parts of water, added to 5 parts of glycerine and a sufficiency of caustic potash to redissolve the precipitate first formed and give an azure solution, possesses the remarkable property of dissolving natural silk. From there to the conclusion that this preparation should be the most perfect insecticide is but a step, since it can dissolve the shell of the insect, the composition of which is very analogous to that of silk. This insecticide, which has not yet been tested in actual practice, would only decompose very slowly, and might act energetically on insects. [Mouillefert has found that ammoniacal sulphate of copper, although more active against phylloxera than blue vitriol, does not kill it, and Pearson reports that eau celeste removes the *Macrodactylus subspinosus* injurious to rose bushes.] Along with all these properties just described eau celeste has grave drawbacks. It is, above all, blamed for causing serious burns, especially when the treatment has to be applied very early. This fact is especially to be dreaded when eau celeste is spread in moist weather when it therefore dries slowly on the leaves; on the other hand, when the sprayings are applied in the strong heat of summer, this defect entirely disappears, and eau celeste is in every way advantageous. These burns, in fact, are easily explained. It has been seen under blue vitriol that the poisonous action of cupric preparations on plants was the more pronounced the more soluble they were in water. Eau celeste contains a cupric compound, as soluble as blue vitriol, and the effect produced at the moment of spraying is thus equally unfavourable to the plant. It is likewise admitted that blue vitriol is poisonous, owing to the sulphuric acid which it contains, and which, in Bordeaux bouillie, is fixed and rendered harmless by the lime. Although sulphuric acid may contribute to a certain extent to the corrosive action of blue vitriol, it is not the chief poisoning principle. For the same reason it is generally admitted that eau celeste burns the leaves, because the sulphuric acid of the blue vitriol used in its preparation is fixed by the ammonia, and that this unstable salt, in decomposing, liberates sulphuric acid, which then burns the leaves. This hypothesis is one of the chief reasons of the use of copper carbonate in place of blue vitriol in the preparation of eau celeste; the latter, in fact, burns the plants much less than ordinary eau celeste.

There is thus great analogy between the action of blue vitriol and eau celeste, both on the plants and on the fungi to be overcome. From the beginning of the use of eau celeste it was to be seen that a solution made from 0·5 per cent. of blue vitriol sufficed to produce the desired effect; the doses have diminished in certain cases as far as 0·1 per cent. of blue vitriol. With such solutions burns are no longer to be feared. In contrast with blue vitriol, which, as it dries on the surface of the leaf, forms small crystals, which dissolving in the dew yield concentrated solutions, burning the leaves where these crystals are accumulated, the eau celeste deposits cupric hydrate on evaporation. The defect of burning the leaves only exists for the eau celeste for the time during which the sheet of liquid takes to dry. As soon as dry the ammonia which holds the copper oxide in solution evaporates, leaving a residue of cupric hydrate, which covers the surface of the leaf and protects it against spores. If rain falls it is only beneficial, because far from dissolving or detaching the cupric film, it only dissolves and removes the sulphate of ammonia, the action of which on the plant may be injurious. Eau celeste, compared with blue vitriol solutions, therefore, possesses the advantage of leaving an adherent deposit on the surface of the leaf, and whilst equally efficacious at the moment of use, has a much more durable action. With an equal dose of blue vitriol, it requires fewer sprayings with eau celeste than pure blue vitriol, which renders this treatment less costly than those in use. There is, however, a third cause, which explains the poisonous action of eau celeste on plants. Whether prepared with or without an excess of ammonia the eau celeste, in drying, disengages ammonia on the surface of the organs attacked, and in greater quantity the greater the excess of ammonia. Now, ammonia is injurious to plants; as soon as the air contains a dose exceeding 70 milligrammes per cubic metre of air, it causes burns already described. To replace Bordeaux bouillie with advantage eau celeste should not be made from more than 0·5 per cent. of blue vitriol or 0·25 per cent. of copper carbonate nor with an excess of ammonia. To be certain that an excess of ammonia has not been used it is well only to add such an amount as will not entirely re-dissolve the precipitated copper hydrate. The chances of burning are thus much diminished. Besides, it is well only to use eau celeste in fine dry weather, so as to let the thin layer of liquid spread on the surface of the plant. To get an eau celeste free from sulphate of ammonia this liquor is prepared as follows (Prillieux): Precipitate the blue vitriol as cupric hydrate with half the quantity of ammonia used in making eau celeste; let this celestial blue precipitate deposit; decant the clear limpid supernatant liquid, which contains all the sulphate of ammonia; add water equal in volume to the bulk of the liquid removed, and add the remainder of the ammonia to dissolve the precipitate; an eau celeste is thus obtained which contains little or no sulphate of ammonia. The same result is obtained by adding to a 0·5 per cent. Bordeaux bouillie the ammonia required to dissolve the precipitated cupric hydrate, then decanting the dark blue supernatant limpid liquid after some time from the deposit formed by the excess of lime and sulphate of lime. This eau celeste no longer contains traces of sulphuric acid nor of sulphate. By taking these precautions in the preparation of eau celeste, and only using it rationally, this liquor is excellent, and especially cheap. A drawback of eau celeste is that it leaves no decisive mark on the leaves. Eau celeste is especially advised to combat cryptogamic diseases in full evolution in circumstances where the use of Bordeaux bouillie would have no effect. In such cases its special properties, its energetic action on the conidiophores and on spores, produce the best results. Its corrosive action on the leaves in the dose required to stop the first attack of fungi in the spring, will always cause it to be inferior to neutral Bordeaux bouillie, but in summer, when burns are not to be feared, the second and third treatments for the year are advantageously made with eau celeste.

*Eau celeste is, therefore, in the hands of the cultivator, a powerful agent for overcoming cryptogamic diseases in full evolution, whilst Bordeaux bouillie is par excellence the preventive remedy which should protect the plant, by killing the germs which are deposited on its surface.*

**Use.**—The use of eau celeste has found numerous advocates in France and Switzerland. *Eau celeste modifiée* has in America in many cases replaced Bordeaux bouillie.

*Phytophthora infestans*, de By. (potato disease).—Mohr advises to overcome this disease in full evolution, 3 lb. blue vitriol, 1 lb. 80—85 per cent. soda ash, and 12 fl. oz. of ammonia of 24° Bé. in 10 gallons of water. Spraying is done in the morning as soon as the dew has evaporated. A dilute solution, used in July, will not burn the leaves.

*Peronospora viticola*, de By. (mildew of vine).—Eau celeste affords cheap summer treatment, especially to stop a sudden outbreak. Mohr advises for June spraying an eau celeste prepared thus: Dissolve 1½ lb. of blue vitriol in 2 gallons of water, add first 8 fl. oz. of ammonia, 24° Bé., then the solution of ⅗ lb. of 80 per cent. soda ash, and make up to 10 gallons. July and August sprayings are made with an eau celeste consisting of 2 lb. of blue vitriol, 9·6 fl. oz. of ammonia, 12 oz. of calcined soda, and 10 gallons of water. In the opinion of several observers a 0·4 per cent. eau celeste suffices. Prillieux doubts its efficacy and prefers a stronger eau celeste to produce an effect on the disease in full evolution and an advantage over Bordeaux bouillie. Kalas' results with Bordeaux bouillie are in a general way better than those obtained with eau celeste. Vines strongly attacked by mildew are greener after treatment with Bordeaux bouillie than after eau celeste.

*Peronospora gangliformis*, de By. (lettuce disease).—Kitchen gardens often suffer from this disease. It would be prevented, according to Prof. Maxime Cornu, by covering the soil with a layer of shavings or straw, previously impregnated with eau celeste. Dung from mushroom beds ought to be drenched with eau celeste, then drained, before being used for lettuces.

*Puccinia graminis*, Pers. (rust of wheat).—Galloway has examined the effect of eau celeste on the evolution of rust, and made the interesting remark that winter wheat, treated every ten days by spraying with eau celeste, is completely freed from rust, whilst it remained attacked when the sprayings were at twenty days' interval. In this last case the diminution of diseased plants was only 33⅓ per cent. These results were disputed by Swingle.

*Puccinia pruni*, Pers. (plum-leaf rust).—Pierce reports that this rust is successfully overcome by an eau celeste of blue vitriol 1 lb., ammonia 26° Bé. 12 fl. oz., carbonate of soda 1¼ lb., in 100 litres of water.

*Podosphæra oxycanthæ*, DC.—Pammel reports that he prevents the fall of the leaves incidental to this disease by ten sprayings, from 6 June to 4 August on grafted cherry-trees and Mahaleb plums with *eau celeste modifiée*. The thirty-five plants treated had 4498 leaves against 1195 on the untreated samples.

*Sphærotheca humuli*, Burr. (strawberry blight).—Humphrey obtained a complete cure of attacked plants and a recrudescence of verdure by treatment with Bordeaux bouillie containing 0·4 per cent. of carbonate of copper and 2 per cent. of carbonate of ammonia.

*Guignardia Bidwelli*, V. and R. (black rot of grapes).—Galloway got good results by the following treatment: Modified eau celeste, containing 0·1 per cent. of copper carbonate dissolved in ammonia and used in four sprayings, 30 April, 15 May, 30 May, and 14 June. The total of the diseased grapes was reduced to 0·6 per cent., against 45 per cent. on the untreated stocks.

TABLE LII.—*Showing Composition of Galloway's Eau Celeste.*

| | |
|---|---|
| Blue vitriol | 3 lb. |
| Soda crystals | 3 ,, |
| Ammonia | 2½ ,, |
| Water | 100 gals. |

Galloway's bouillie applied in six sprayings in fine weather, in eight sprayings at fifteen days' interval in bad weather, was still more active.

TABLE LIII.—*Showing the Percentage of Sound Grapes on Untreated Vines, and on Vines Treated by Eau Celeste made by Two Different Formulæ.*

| | Percentage of sound grapes. |
|---|---|
| Untreated vines . . . . . . | 38·3 |
| Vines treated by eau celeste, formula I . . | 91·32 |
| ,, ,, ,, ,, II . . | 98·06 |

*Gloeosporium frutigenum*, Berk. (bitter rot of apples).—Goff and Nijpels state that three sprayings with eau celeste is a sufficient protection for apples.

*Fusicladium dentricum*, Fuckel (apple scab).—Galloway and Goff caused this disease to disappear entirely with four sprayings of eau celeste containing 45 grammes of copper carbonate dissolved in ammonia per 100 litres of water [45 parts by weight in 100,000 parts by measure]. It is necessary to make the first spraying before blossoming, the second immediately after blossoming, and the two last at fifteen days' interval.

*Fusicladium pirinum*, Fuckel (pear scab).—These are overcome in the same way (Mohr).

*Entomosporium maculatum*, Lev. (leaf scald of the pear-tree).—This disease may be removed by spraying with an *eau celeste modifiée* containing copper carbonate 1 lb., ammonia 26° Bé. $\frac{3}{4}$ lb., water 100 gallons. To prevent burning the leaves an excess of ammonia must be avoided. Pammel recommends as many as eight sprayings, 8, 20, and 27 June, 9, 11, 18 and 21 July, and the last 1 August.

*Colletotrichum Lindemuthianum*, Br. and C. (anthracnosis of the haricot, etc.).—According to Halsted, modified eau celeste acts better than Bordeaux bouillie against this disease. In Canada a peculiar system of disinfecting seed haricot beans is used. It is an eau celeste containing about 1 per cent. copper carbonate dissolved in the necessary amount of ammonia. The results obtained by one hour's disinfection are as follows :—

TABLE LIV.—*Showing the Result of Disinfecting Haricot Bean Seed with Eau Celeste.*

| | Percentage of plants reared. | Healthy pods, per cent. |
|---|---|---|
| Disinfected haricots . . . . | 73 | 79 |
| Untreated ,, . . . . | 84 | 43 |

*Cercospora circumcissa*, Sacc. ("shothole fungus," spots of the leaf of the plum-tree and almond-tree).—Galloway reports that an eau celeste containing 1·42 lb. of copper carbonate dissolved in 204 gallons of water and the necessary ammonia may be used against disease of the peach and almond trees, because it scarcely burns the leaves. To overcome the *Cercospora* a first treatment is given as soon as the leaves appear, the second ten days later, and a third at fifteen days' interval. Pierce thus obtained 80—98 per cent. of healthy leaves against 2—8 per cent. on the untreated.

*Cercospora angulata*, Wint. (spots of the leaves of the gooseberry).—Pammel got good results by seven sprayings made between 6 June and 15 August.

*Septoria rubi*, West. (spots of the leaf of the bramble and raspberry bushes).—Whilst the raspberry is sensitive to the action of eau celeste, good results are obtained if it is used to combat the *Septoria* of the bramble. Goff obtained the following results :—

TABLE LV.—*Showing the Effect of Spraying Bramble Bushes with Eau Celeste.*

| Kind of crop. | First series, lb. of fruit. | Second series, lb. of fruit. |
|---|---|---|
| Brambles sprayed six times . . | 224 | 488 |
| ,, untreated . . . | 168 | 452 |

*Cladiosporium fulvum*, Cooke (tomato leaf rust).—Jenkins and Britton found that modified eau celeste had no good effect, whilst Bordeaux bouillie entirely removed this disease.

*Lemon Warts*.—Swingle and Weber advise modified eau celeste to prevent lemon warts. For this purpose they advise the first treatment after the fall of the petals, the second two or three weeks later, the third after the fall of the last flowers, and the fourth when the fruits are the size of a pea. In moist weather favourable to the extension of the disease, it is necessary to multiply the treatments.

**Phosphate of Copper,** $CuHPO_4$.—**Preparation.**—By adding a solution of phosphate of soda to a solution of blue vitriol.

**Use.**—Fairchild prepared a bouillie by precipitating 4 lb. of blue vitriol by 7 lb. of phosphate of soda, and made the bulk up to 100 gallons. This preparation whilst having the properties of Bordeaux bouillie, covered the leaves better than that preparation. In the treatment of *Entomosporium maculatum*, Lev. (leaf scald of the pear-tree), the bouillie gave good results; it did not seem to damage the leaves. The results obtained by Galloway against the rusts of oats and wheat were not remarkable. The plots treated 6, 16, and 20 June, as well as July, showed no rust, but the yield in grain was only 83 per cent. of the usual yield.

**Borate of Copper,** $CuB_4O_7$.—**Preparation.**—By adding a solution of 50 grammes of borax to a solution of 25 grammes of blue vitriol; or by the action of boric acid on copper hydroxide.

**Use.**—Copper borate has been recommended by Lodemann as an antiseptic and anticryptogamic preparation with the properties of copper salts and of borax. Fairchild used it in a bouillie of 4 lb. of blue vitriol and 4·3 lb. of borax in 100 gallons of water to destroy *Entomosporium maculatum* (spots of the leaves of the pear-tree). This bouillie adheres better than ammoniacal Burgundy bouillie. Galloway treated summer wheat and oats against rust by making four sprayings with this bouillie, 6, 16, and 20 June, and 5 July. He obtained plots of wheat with no rust, and yielding 9 units of grain against 8·5 on the untreated plots. With a bouillie containing more borax—it consisted of 70 grammes of blue vitriol and 180 grammes of borax in 100 litres of water—he obtained on winter wheat fields free from rust by spraying every ten days.

**Ferrocyanide of Copper.—Preparation.**—By adding a solution of yellow prussiate of potash to one of blue vitriol, until all the copper is precipitated.

**Use.**—Galloway tried to overcome the rust of winter wheat by spraying the wheat fields every ten days with this preparation. He used a bouillie of 7 oz. of blue vitriol and 16 oz. of yellow prussiate in 62½ gallons of water. By this treatment he diminished the diseased plants 30 per cent. A bouillie consisting of 4 oz. of blue vitriol and 6 oz. of yellow prussiate used in four sprayings, 6, 16, and 20 June, and 5 July, has considerably increased the yield of summer wheat and oats. It fell to 7 units against 8·5 on untreated plots.

# CHAPTER XVI

COPPER ACETO-ARSENITE (EMERALD GREEN, PARIS GREEN)—COPPER ARSENITE (SCHEELE'S GREEN)—COPPER SILICATE—COPPER CARBONATE — BORDEAUX BOUILLIE CELESTE — VERDIGRIS COPPER ACETATE—VARIOUS BOUILLIES.

**Aceto-Arsenite of Copper, Emerald Green, Paris Green.—Definition.**—The aceto-arsenite of copper sold in commerce under the name of [emerald green], "Paris Green," "Schweinfurth green," is a double arsenite and acetate of copper.

**Preparation.**—By dissolving 4 lb. of white arsenic in 5 gallons of water, and on the other hand, 5 lb. of verdigris in 5 gallons of water, and mixing the two liquids. The mixture is boiled for some time, then a little acetic acid is added. To prepare a bouillie, it suffices to mix 1 lb. of emerald green in a little water, add milk of lime containing 1 per cent. of quicklime, and make up the paste to 10 gallons of bouillie. This mixture of cupric hydrate [acetate] and arsenite is much used in America. Commercial Paris green contains 55·34—60·16 per cent. of arsenic ($As_2O_3$) and 27·7—30·9 per cent. of cupric oxide ($CuO$).

**Properties.**—Commercial aceto-arsenite of copper is not completely insoluble in water, and thus possesses an injurious action on the plants treated. This defect disappears if the acetate of copper be converted into hydrate by quicklime, by mixing the emerald green with lime. Aceto-arsenite of copper freshly prepared is a precipitate fine enough to remain suspended in water. That is not so with the emerald green of commerce. If a bouillie be prepared from the latter, as is generally done, the granular precipitate falls to the bottom of the liquid, and it is necessary to use a sprayer fitted with an agitator to distribute the salt regularly on the trees. Trials by Lintner to determine whether arsenites mixed with soil were absorbed by plants led to the conclusion that plants only absorb arsenites with great difficulty, and only in cases where it is placed in large doses in direct contact with their roots. The aerial organs do not dissolve insoluble arsenites deposited on them by spraying. The ash of potato plants, which has been sprayed with a bouillie of arsenite of copper, does not contain arsenic. Baily obtained the same results with peach-trees treated with emerald green, and Fletcher on apple-trees similarly treated. Scheele's green, being insoluble, behaves like arsenite of lime. When the product is pure, that is to say, when it contains no unconverted arsenite of soda, its action on plants in insecticidal doses is, so to speak, *nil*, and in many cases it may be employed in 0·05 and 0·1 per cent. bouillie. On the other hand, the action of Paris green makes itself felt very energetically when it is not mixed with lime. Baily found that it is less injurious when very finely divided. Whitehead gives as harmless doses, 40 grammes in 100 litres of water for apple-trees, 45 grammes in 100 litres of water for pear-trees and gooseberry bushes, and 60 grammes in 100 litres of water for plum-trees and currant bushes. (For grammes per 100 litres read also parts by weight per 100,000 parts by measure.)

Peach-trees are the most sensitive to copper arsenites; that is not surprising, since other and even insoluble copper salts, even in minimum doses, induce the total or partial fall of the leaves of that tree.

**Action of Arsenites of Copper on Insects.**—The arsenite and aceto-arsenite of copper are violent poisons to all insects, which in nibbling the leaves absorb a small quantity.

**Use.**—Arsenical insecticides have been in use since 1859. In 1872 Dr. Le Baron recommended the use of Paris green against the caterpillar of the citigrade spider. In 1878 Haynes tried this product against the pyralis of the apple-tree, and this trial was followed by others. In 1887 the use of arsenical salts was recognized as the most efficient treatment for phytophagous insects. Arsenical sprayings now rarely consist of arsenites alone; they are mixed with substances which facilitate their application by keeping the arsenites in suspension in water or impart to them anticryptogamic properties. The substances with which they are mixed should be of such a nature as not to render the arsenites soluble; thus ammonia eau celeste, pure blue vitriol, soap, and ferric chloride are excluded. A mixture highly valued in America is that of emerald green and Bordeaux bouillie. Coquillet advises to increase the adherence by the addition of resins rendered soluble by soda. For the same purpose 2 per cent. of molasses may be incorporated or 1 per cent. of farina (potato starch). This later substance has also the advantage of maintaining the precipitate of arsenite of copper longer in suspension in the liquid. Petrol presents no advantage.

**Method of Use.**—1. *In the Dry State.*—Insoluble arsenites are used in the dry state as powder when the want of water renders spraying the arsenites as bouillies impracticable. To prepare an insecticidal powder 1 lb. of Scheele's green is mixed with 100 lb. of gypsum, 100 lb. of slaked lime, or 67 lb. of farina, or with mixtures of 50 lb. of gypsum and 50 lb. of farina, or with 67 lb. of farina and 33 lb. of gypsum. Dry treatment can only be applied to small-sized plants, owing to danger to the operator. It is very much used in America against the insects of the cotton plant, and various altises, cabbage caterpillars, etc. The insecticide is not so evenly distributed in the form of powder as it is in bouillies; it is done with bellows, hand, or sieve. The operator spreads it whilst walking backwards against the wind. Calm weather is chosen early in the morning when the plants are covered with dew or moistened by rain.

2. *As Bouillies.*—Arsenites of copper are used as bouillies chiefly in arboriculture. It is preferable to precipitate the arsenite of copper on the spot by mixing arsenite of soda and blue vitriol with the addition of a little lime rather than make commercial Scheele's green or emerald green into a paste. A finely-divided precipitate is thus obtained which keeps in suspension and allows the insecticide to be evenly distributed. The best all-round proportions are 0·08 per cent. of copper arsenite and 0·08 per cent. of lime (8 lb. per 1000 gallons). From 3—5 hectolitres

of this bouillie are sprayed per hectare (26·4—44 gallons per acre). Spraying should be done in dry weather without dew and renewed if rain washes the leaves before the insecticide has acted, that is to say, within twenty-four hours. In arboriculture, to obtain the object in view it is necessary to make three to six sprayings per annum. These should be made at epochs determined by the habits of the insect to be overcome.

**Precautions.**—By an order of 1846 the use of arsenites for the destruction of insects was forbidden in France. But in spite of that injunction, owing to the success obtained in America with these insecticides, their use has extended in France. Arsenites are true poisons which should be guarded against; however, by operating with precaution the treatment ceases to be dangerous. But the operator, after the operation, should wash himself conscientiously, face and hands, and brush his clothes. He should never forget that he is working with a poison. It has been objected, and still is objected in France, that their use on vegetables and on fruits is a danger to the public health. However, in America, where thus treatment is practised everywhere no case of poisoning has been reported. The Americans have seriously examined this drawback and made numerous analyses of fruit and vegetables treated with arsenite, but found that the poison does not enter into the plant treated, and that remaining on the surface completely disappears after twenty to twenty-four days. The amount of arsenic spread on plants is so minute that if they were consumed even shortly after treatment it would require an exceptionally large quantity to produce a poisonous effect. From the analysis of the cabbages treated, Gillette calculated that a person would require to eat 28 heads in a single meal to feel the symptoms of poisoning. In the same way, Riley from experiments made on apples so treated, calculated that one would require to eat several 26 gallon barrels to be poisoned. Three weeks after the first treatment Fletcher by analysis found no trace of arsenic on the apples. Plants intended for consumption do not therefore present any danger to the consumer after that lapse of time. However, if such treatment be applied in hot countries prudence must be exercised, for the absence of summer rains might render the presence of this poison on the edible parts of the plant dangerous. Moreover, its use must be avoided during flowering, for the bees and insects indispensable to the fertilization of the flowers risk being killed; further, practice has shown that flowers are rendered sterile if this treatment is applied at the time of blossoming.

Arsenical treatment is excellent when applied on vegetables which are not to be consumed immediately and in countries where frequent rains remove all trace of the poison.

The profit is considerable, for no treatment is more advantageous to the plant. The following figures published in America refer to orchards only. During the ten years previous, the quantity of apples which without the treatment became wormy was calculated as 50—75 per cent. of the total crop. It is estimated that the plus value was 4s. to 10s. per barrel of 26·4 gallons, with an expense of 5d. per tree. From amongst several the case of a Virginia orchard is quoted of which one-third was subjected to the arsenical treatment, whilst the other two-thirds remained untreated. In the treated portion the amount of healthy fruit exceeded by 50 per cent. that of the untreated portion, and by 100 per cent. as regards market value.

**Use against Injurious Fungi.**—*Fusicladium dentriticum*, Fuckel (apple scab).—By treating apple-trees with emerald green, against injurious insects, apple scab is, likewise, and to a great extent, diminished. Goff obtained 50 per cent. of immaculate apples against 30 per cent. on untreated trees with four sprayings of 0·06 per cent. bouillie of emerald green neutralized by milk of lime. Galloway states that 0·05 per cent. bouillie with a little lime is superior to all other products.

*Phytophthora infestans*, de By. (potato disease).—Galloway greatly recommends to combat simultaneously both the potato disease and the Colorado beetle a bouillie consisting of 100 litres of Bordeaux bouillie with 4–10 grammes of emerald green (that is, 4—10 parts of emerald green by weight to 100,000 parts by measure).

**Use against Injurious Insects.**—The injurious insects combated in America by this process are very numerous, and will now be enumerated, describing only those which ravage European plants and those of America which are of particular interest, because they may eventually prove dangerous to our crops.

*Anthonomus pomorum* (apple weevil).—The cleaning of the trunk of the tree and its branches and coating with lime Bordeaux bouillie or with acidified green vitriol are treatments capable of destroying the insect in its winter shelter. Spraying with copper arsenite a little before flowering and during the summer may poison and destroy the adult insects which escape the winter treatment. The results of this method are perfect. Goethe does not share this opinion.

*Anthonomus grandis*, Boh. (cotton boll weevil) and *Alabama argillacea*, Hübn. (leafworm). For dusting cotton from airplanes a useful preparation included one part Paris green, one-half part lime, and five parts white flour. This combination worked very satisfactorily in the plane and spread through the cotton and adhered to the plants very well. The adhesive qualities provided by the flour seemed to hold the material together fairly well in the air. So far as worm control is concerned, the effect of the Paris green was much more pronounced than that of any other chemical used. In every instance practically complete control was secured immediately after such applications, and it was thus shown that probably the instances of partial control with either calcium arsenate or lead arsenate were due to the lower toxicity of these materials rather than to faulty distribution. In ordinary field leafworm control work, a mixture of about 5 to 10 parts of lime to 1 of Paris green is always used, and is distributed at the rate of from 2 to 5 pounds per acre. In the airplane work with the flour mixture, the Paris green was used at the rate of approximately 1½ pounds per acre, and practically complete worm control was found in every field treated.

*Zabrus Gibbus*[1] F.—An arsenical spraying at the right time kills these larvæ.

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[1] ZABRUS GIBBUS (zabrus of cereals).—Black Coleoptera, 1½ centimetres long, with an accentuated prominence of the throat. It attacks corn crops in June in the night and devours the milky juice. The larvæ are as injurious as the perfect

*Crioceris asparagi* (the asparagus beetle).—Vivien recommends for the destruction of the perfect insects and their larvæ sprayings with a bouillie prepared thus: Mix a solution of 2 lb. of blue vitriol in 8 gallons of water with 0·4 gallon of a concentrated solution of sodium arsenite of 15° Bé.; then add the requisite amount of carbonate of soda to alkaline reaction (it takes about $\frac{1}{2}$ lb.); then it is again acidulated whilst adding $\frac{1}{20}$ of a lb. of blue vitriol. The bouillie is made up to 10 gallons.

*Altises.*—These multiple generations of small voracious insects, numerous species of which exist, may be combated by copper arsenites in powder or bouillie.

*Haltica ampelophaga*, Guer. (altise of the vine, *Pucerotte*). Gaillot's bouillie, the composition of which is given under the heading "Arsenite of Copper" (p. 289), and which is nothing but a Bordeaux bouillie containing a little Scheele's green, must be used in this case, yet the same result is obtained by simply adding emerald green to a cupric bouillie.

*Psylliodes affinis*, Payk. (altise of the potato).—As an efficient method of destroying fungi spores and insects, such as the *Dryophora* and the altise of the potato, Woods recommends bouillies consisting of a mixture of 120 parts of emerald green in 1000 parts of Bordeaux bouillie, or 120 parts of emerald green and 750 parts of lime in 100 parts of water.

*Haltica Chalybea* (plum altise). Britton states that arsenical bouillies destroy this altise. The perfect insects are destroyed by 0·2 per cent. and the larvæ by a 0·06 per cent. bouillie.

*Cassida nebulosa.*—In Saxony the arsenical bouillie has proved itself more efficient than such insecticides as soapy emulsions of petroleum, vinegar, slaked lime in powder.

*Silpha*,[1] L.—Opaque silph of the beet.

*Silpha atrata* (black silph).—Silphs like the *Dryophora* of the potato are killed by cupro-arsenical bouillies with an emerald green or Scheele's green basis.

**Treatment by Powders.**—An intimate mixture of 1 kilogramme (2·2 lb.) in 100 kilogrammes (220 lb.) of very finely divided gypsum, damaged flour, ashes, or a mixture of these different substances, is spread by hand on the dew-charged leaves. This dose suffices for 1 hectare ($2\frac{1}{2}$ acres). The operator must so manœuvre as to have the wind behind him.

**Treatment with Bouillies.**—There is distributed, preferably by the spraying machine "Eclair," a bouillie of 0·2—0·24 per cent. of Scheele's green, or 0·5 per cent. of lime and 0·2 per cent. of emerald green. Four

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insects; they are yellow, with cross plates; they remain hidden in the day in the burrows dug in the soil, and issue at night to devour the wheat in the blade; they commit their depredations in autumn as well as in spring, for they take two to three years to metamorphose.

[1] SILPHS.—Silphs preferably attack decomposing animal matter; but certain species form an exception and attack cultivated plants. SILPHA OPACA (beet carrion beetle). SILPHA ATRATA (black silph).—Coleopteræ, 1 centimetre long, entirely blackish-brown, the corselet is highly developed, and in the form of a shield. The larva attains $1\frac{1}{2}$ centimetres in length; it is black and resembles a large wood louse. These insects cause serious damage to beet fields.

hectolitres of bouillie per hectare are applied, say 35 gallons per acre. Gaillot's bouillie has been tried with success in the North of France, and in Hérault the larvæ die in twenty-four hours. Sorauer advises the use of a bouillie of 1 per cent. Scheele's green and 0·2 per cent. of flour.

*Leptinotarsa decemlineata* (Colorado beetle).—In America cupro-arsenical bouillies have been used with success for many years against this voracious insect. This treatment has the advantage of destroying many other insects at the same time and of protecting the plant against potato disease, *Phytophthora infestans*, de By.

*Galeruca calmariensis* (galeruca of the elm).—In the U.S.A. arsenical bouillies are used to destroy the larvæ of this *Chrysomelide*, which rapidly causes the death of the finest avenue trees. But gigantic spraying machines and powerful pumps mounted on trucks are required, capable of throwing a jet to the top of the tallest trees.

*Lochmœa capreœ*, L., var. *pallidipennis*, Küst. This Galerucid has been actively attacking the willow trees which border the vineyards in the Caucasus. Experimentally, Paris green, 1 lb. to 30 gals. water and 10 lb. lime, painted on the younger growth before the buds open (1st April) has given good results.

*Epilachna*[1] or *Coccinella globosa*, Ill., is destroyed by spraying emerald green in powder on the plants (Sajo). Likewise—

*Agriotes lineatus*, L. (wire-worm); *Entomoscelis adonidis*, Pall.

*Weevils*.—Stift advises spraying the ravaged plants.

*Scolytes*.—Fletcher advises coating the tree with oil paint containing emerald green.

*Chætocnema tibialis*, Ill.—This altise, injurious to beets in Hungary, may be destroyed by 0·185 per cent. emerald green (Gémési).

*Cleonus sulcirostris*, L.—This beetle, injurious to beets, may be overcome by 0·5—2 per cent. emerald green bouillie. The first spraying ought to be done as soon as the leaves appear, the second at the time the insects copulate, say near end of May.

*Solenopsis geminatus*.—This ant, which does much damage to the young shoots of peach and plum trees, may be combated by spraying with Bordeaux bouillie containing 0·05 per cent. of emerald green and 4·5 per cent. of molasses.

*Grasshoppers*.—A poison-bait recommended against grasshoppers, consists of 100 lb. of finely cut green autumn rye or wheat plants, with 5 lb. of white arsenic or Paris green, 5 lb. of common salt, and water to moisten.

*Gryllus assimilis*, F. (common field cricket).—Experiments with poison baits for this cricket in S. Dakota have led to the adoption of a formula consisting of 25 lb. of bran, 1½ lb. of white arsenic or Paris green. 1 U.S. gallon of molasses and 3¾ U.S. gallons of water. This should be applied in the cool of the evening, 4 lb. of the dry bran being used per acre. In lucerne fields, the bait should be applied after the first cutting of the hay. Where irrigation is practised, the cut-over lucerne should be irrigated before the bait is applied; in other places the bait should be applied after heavy rain. In the tests, one application killed at least 50 per cent. of the crickets.

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[1] EPILACHNA GLOBOSA. *Coccinella globosa*.—The larvæ of this Coleoptera riddles the leaves of trefoil, lucerne, and potato.

The larvæ of the *Tenthredos* (saw-flies) are successfully overcome by cupro-arsenical bouillies.

*Ptereneus ribis*, Scop. (gooseberry saw-fly).—This insect is successfully overcome in Canada, likewise *N. pallidiventris*.

*Eriocampa adumbrata* (cherry-tree saw-fly).—Coquillet successfully used a cupro-arsenical bouillie rendered adherent by the addition of pine resin dissolved in potash.

It is easy to destroy caterpillars by spraying with cupro-arsenical bouillie, for these insects are then the victims of their voracity. The butterflies most injurious to arboriculture which have been treated most successfully belong to the Tortricides, to the Pyralides, and to the Tineides.

Against the caterpillar of the raspberry moth the British Ministry of Agriculture recommends: 1 oz. of Paris green paste, 1 lb. of quicklime, 10 gallons of water. The Paris green should be worked up with a little water and added to the lime ready-slaked with the remainder.

*Carpocapsa pomonella* (codlin moth).—The damage caused by this pyralis is considerable. Action must be taken to destroy it very soon after the hatching of the caterpillar, for it lives on the leaves until the apples are big enough to be penetrated. The first spraying should be made after the fall of the flower, and the second a week later, before the calyx is re-closed and the fruit reversed on the stem. Spraying during flowering must be avoided, for it would destroy the insects which fertilize the flowers, and render the latter barren.[1]

*Carpocapsa funebrana* (pyralis of the plum-tree).—Spraying with cupro-arsenical bouillie made at the moment of the fall of the corolla of the flowers and on the young tied fruit poisons the grubs before they can pierce inside the fruit.

*Hyponomeuta malinella*, Jell (small ermine moth of the apple-tree). —Emerald green sprayings are in general use in certain countries.

*Agrotis segetum* (common dart moth).—To prevent the damage caused by this voracious grub, which is called the grey-worm, it suffices to make a cupro-arsenical spraying on the young spring shoots threatened. It is not a case of beet crops alone which have been protected in the North of France and in Hérault, but also the gardens which in the spring time suffer much from the hibernating caterpillars of the *Noctua* which attach themselves to the young shoots, and cut the stems of small plants. They escape search and sight, because they hide during the day, and only commit their ravages at night. Fletcher, a Canadian Government entomologist, advised for the destruction of grey-worm the use of a mixture of bran and emerald green. The wheat bran which is used in the mixture is previously moistened and sugared, then spread between the rows of transplanted plants. As soon as the poison is on the soil, the plants are not attacked by the grubs, which take themselves off rapidly, or die of eating it.

*Cheimatobia brumata*, L. (winter moth, Evesham moth).—The grub of this butterfly, which is particularly injurious in the spring to the buds of apple-trees, pear-trees and plum-trees, is overcome by cupro-arsenical bouillies, sprayed on the buds and the young shoots. This process has been used for a long time in America and in France.

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[1] *Translator's Note.*—Spraying during flowering courts risk of enclosing poison in core of apple.

*Pieris rapæ*, L., *Pieris brassicæ* (white cabbage butterfly).—Cupro-arsenical bouillie, spread on the cabbages, is generally used to destroy the caterpillars. The rains suffice to wash the cabbages and render them fit for food.

*Hadena brassicæ* [1] (noctua of the cabbage).—A mixture of gypsum and emerald green dusted on the cabbages gives good results.

*Leucania unipunctata*,[2] Haw.—Fletcher advises sprinkling meadows with a mixture of 1 lb. of emerald green and 25 lb. of farina.

*Protoparce paphus*, Cram. This Sphingid, which is a severe pest of tobacco in Bahia, may be combated by spraying with 1 lb. Paris green and 5 lb. slaked lime in 100 gals. water. An alternative formula is 8 lb. lead arsenate and 10 lb. wheat flour in 100 gals. water.

*Acari.*—Amongst the phytoptides may be quoted *Eriophyes ribis*, Nal., or *Phytoptus ribis*. In America it is overcome by spraying with 0·06 per cent. emerald green, 0·12 per cent. of wheat starch or soft soap. The first spraying is made in spring, the second in autumn shortly after the fall of the leaf to prevent the acari from taking shelter in the buds.

**Copper Arsenite,** $Cu_2As_2O_5$.—**Preparation.**—By precipitating a solution of arsenite of soda by a solution of blue vitriol. The green precipitate which forms, filtered, washed and dried, is known as *Scheele's green.* To prepare an insecticidal and anticryptogamic bouillie Gaillot recommends to dissolve 1 lb. of white arsenic and 1 lb. of soda ash in a gallon of boiling water, and then to add with constant stirring a solution of 10 lb. of blue vitriol in 10 gallons of water. There is then added a milk of lime, made from 10 lb. of lime and 10 gallons of water, then a solution of 20 lb. of molasses in 2 gallons of water; the whole is then diluted to make 100 gallons of bouillie which is nothing less than a Bordeaux bouillie containing a little Scheele's green.

**Properties.**—Scheele's green is insoluble in water; when it is freshly prepared the precipitate is so fine that it remains a long time suspended in the liquor, which is not the case with the dry commercial product.

**Use.**—It is used under the same conditions as emerald green (Paris Green, p. 283).

**Silicate of Copper,** $CuSiO_3$.—**Preparation.**—Dissolve 4 lb. of blue vitriol in 50 gallons of water, and add after cooling whilst stirring a solution of $12\frac{1}{4}$ lb. of silicate of soda in 50 gallons of water. A gelatinous precipitate, insoluble in water, is formed.

**Properties.**—Copper silicate was prepared by Fairchild, with the object of obtaining a more adherent cupric bouillie than Bordeaux bouillie. He, however, found, contrary to his expectations, that this bouillie did not adhere so well as normal Bordeaux bouillie. Copper silicate, less soluble than copper hydrate, cannot perform the same services as the latter, and although the silicate of soda used in its preparation is endowed with antiseptic properties, the insoluble product which it forms with copper is, owing to its insolubility, an inert body.

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[1] HADENA BRASSICA (cabbage moth).—*Mamestra brassicæ.*—The caterpillars of several noctua ravage cauliflowers and ordinary cabbages, especially when they are hearted. They form numerous holes and penetrate to the core.

[2] LEUCANIA UNIPUNCTATA.—The caterpillars of this tortrix penetrate inside grass stems and thus greatly injure meadows.

**Use.**—Fairchild used the silicate of copper bouillie against *Entomosporium maculatum*, Lev. (leaf scald of the pear-tree), and found that it did not damage the leaves of the tree. That is not surprising, as only soluble cupric salts and their derivatives are poisonous to plants.

**Carbonate of Copper**, $CuCO_3$ (Burgundy bouillie).—**Preparation.**—By adding a solution of a copper salt to a solution of carbonate of soda. To convert 1 kilogramme of blue vitriol, $CuSO_4,5H_2O$, into carbonate of copper, it requires theoretically 453 grammes of dry sodium carbonate or 1146 grammes of soda crystals, $Na_2CO_3,10H_2O$.

$$\underset{\substack{\text{Copper}\\\text{sulphate.}}}{CuSO_4} + \underset{\substack{\text{Sodium}\\\text{carbonate.}}}{Na_2CO_3} = \underset{\substack{\text{Sodium}\\\text{sulphate.}}}{Na_2SO_4} + \underset{\substack{\text{Copper}\\\text{carbonate.}}}{CuCO_3}$$

The Burgundy bouillie designed by Masson to overcome parasitic fungi is merely carbonate of copper suspended in a given amount of liquid. It is prepared thus: (1) Dissolve 20 lb. of blue vitriol in 5—6 gallons of hot water, and add thereto after cooling a solution of $8\frac{3}{4}$—9 lb. of soda ash or 23 lb. of soda crystals, and dilute the whole to 100 gallons with water. (2) Dissolve each compound in 50 gallons of water and mix the solutions as cold as possible at the time of use. The second bouillie is better than the first. To obtain a quite neutral bouillie soda ash must be used, for soda crystals, which normally contain 62·8 per cent. of water, are efflorescent, and a neutral bouillie cannot be prepared from them without groping in the dark. Moreover, they always contain larger or smaller quantities of sulphate of soda. The limpid liquid which separates from the blue precipitate after the bouillie has settled should neither be acid nor alkaline; if blue litmus paper dipped in the liquid turns red, carbonate of soda must be added; if red litmus paper turns blue, blue vitriol must be added.

**Properties.**—Carbonate of copper is insoluble in water but soluble in organic acids. The deposit formed on the leaves by spraying with Burgundy bouillie may become soluble as the cupric hydrate of the Bordeaux bouillie and eau celeste, or by the juices transpired by plants, or by water containing carbonate of ammonia or carbonic acid. The amount dissolved being very small, the plant is never in contact with a poisonous amount of soluble copper salt, and Burgundy bouillie does not burn, except when prepared with a great excess, or with an insufficient amount of carbonate of soda. In making Burgundy bouillie, not more than 2 kilogrammes of blue vitriol should be used. This quantity is already very strong, and as was the case in other bouillies it has been reduced in modern Burgundy bouillie to 0·3 per cent. Carbonate of copper freshly prepared by mixing cold solutions of the ingredients is gelatinous, and it is preferably in this form that it should be spread on the leaves to get the maximum adherence and produce the best effect; as it does not preserve this gelatinous condition long, the bouillie must be used immediately after it is made. In fact after eight to ten hours copper carbonate becomes granular, and ends by being converted into a heavy, sandy precipitate, and thus the bouillie loses a portion of its good qualities. This conversion would appear to be accelerated by an excess of carbonate of soda. It already happens when 2·6 kilogrammes of soda crystals are used for 2 kilogrammes of blue vitriol, whilst with 2·3 kilogrammes, the theoretical amount required, this conversion does not occur until after twenty-four hours. Many bouillies are thus intentionally made with a small excess of blue vitriol, which cannot injure the plant, and which strengthens slightly its action on fungi. If Burgundy bouillie be made hot, the resulting carbonate of copper is granular and crystalline. Its anticryptogamic action is perceptibly inferior to that of gelatinous copper carbonate. A bouillie is often used prepared with 0·4 per cent. of blue vitriol and 0·4 per cent. of soda crystals, or even 0·3 per cent. of blue vitriol with the same amount of soda crystals. Commercial copper carbonate always granular, though excellent to prepare modified eau celeste, is unsuitable for the preparation of a normal Burgundy bouillie. If nevertheless it is to be used, it must first of all be reduced to the state of paste by means of a little water, adding thereto whilst stirring the rest of the water, keeping the bouillie generally more concentrated than those obtained by precipitation from blue vitriol. The adherence of this bouillie is much less than that of Burgundy bouillie prepared from blue vitriol. Gerard, Muyssen, and Leplæ consider gelatinous carbonate of copper adheres better than cupric hydrate, and the duration of the action longer than that of Bordeaux bouillie. This difference was especially marked when the Bordeaux bouillie contained a great excess of lime. However, the adherence of a neutral Burgundy bouillie may now be considered as great as that of a normal Burgundy bouillie.

**Use.**—Its ready preparation, its uniform composition, its good adherence, its great fluidity not obstructing the spraying machines, have greatly helped to popularize Masson's bouillie, and it has met with a general reception, especially in Germany and in America. It may be used with an equal blue vitriol content, wherever Bordeaux bouillie gives good results. It is especially recommended in certain cases. Weiss regards it as superior in the disinfection of purchased onions and tubers, which by steeping for one to two hours in a 1 per cent. bouillie are disinfected. A twenty-four hours' steep does not injure them. Fairchild points out the remarkable results obtained in the struggle against *Entomosporium maculatum*, Lev. (leaf scald of the pear-tree). Its action is surprising on the larvæ of the gooseberry saw-fly (*Ptereneus ribis*, Scop). To destroy it as soon as the false caterpillar appears, a spray is applied of 2·5 per cent. of blue vitriol and 2·5 per cent. of carbonate of soda. In less than an hour the larvæ die, blacken, fall, and its ravages are stopped.

**Bordeaux Bouillie Celeste.**—This bouillie is a mixture of insoluble copper carbonate and soluble bicarbonate.

**Preparation.**—Dissolve 1 kilogramme of blue vitriol in a few litres of hot water, and add after cooling 870 grammes of carbonate of soda, then dilute to 100 litres. A proportion of 90 per cent. of copper is precipitated as insoluble carbonate, and the remaining 10 per cent. of copper is converted into soluble bicarbonate. This small amount of dissolved copper is not enough to cause the bouillie to burn the trees, but it suffices to impart to the bouillie the anticryptogamic properties of eau celeste. Bordeaux bouillie celeste, recommended by Fery, combines the properties of the anticryptogamic Burgundy bouillie and eau celeste. It is one of the best anticryptogamic bouillies.

**Basic Acetate of Copper.**—**Preparation.**—By the action of acetic acid on copper.

Commercial verdigris consists largely of basic acetate of copper. The verdigris industry is largely localized in the South of France. The favourite method of manufacture consists in corroding sheet copper by the acid marc of grapes. The marc is chosen as rich in alcohol as possible. It is preserved before use in vats, where it is strongly compressed without access of air. The sheets of copper used weigh about 100 grammes (say 3½ oz.), are 6 centimetres (say 2½ inches) wide, 16 centimetres (say 6½ inches) long, and 1 millimetre ($\frac{1}{25}$ inch) thick. When the marc is to be used, it is taken from the vats and air admitted to convert the alcohol into vinegar or acetic acid. The fermentation which ensues raises the heat to 40° C. (104° F.). When the alcohol of the marc is converted into acetic acid, a little vinegar is added to strengthen its action if it be insufficient, then it is put in contact with copper. New copper with a smooth surface only being attacked difficultly the sheets undergo a preparation which consists in rubbing them with a pad dipped in verdigris acidulated with vinegar. After drying them in the sun, they are submitted to a temperature of 60 – 70° C., which greatly facilitates the first attack. They are then brought quite hot and arranged in layers on the marc, spread out on the ground of a special spot; a layer of marc is spread on them, a fresh layer of copper sheets, and so on until the mass rises 1 metre above the ground. Under the influence of the heat the acetic acid attacks the copper sheets. After six to eight days the marc bleaches; it is exhausted. The green layer formed on the plates is not yet verdigris. To finish the operation the plates are laid on supports in a stove heated to 30° C. After twenty-four hours the supports are dipped into water at 30° C. (86° F.), where they remain four to five days. This steeping is repeated five to six times. The green crust of verdigris has then dissolved the copper and formed a blue mass of basic acetate of copper. It suffices to scrape this crust, which is commercial verdigris. It comes to market in two forms: (1) As a product containing no moisture, and termed *Verdet gris extra sec*, containing 34—35 per cent. of copper. (2) As a still moist product, containing 25—42 per cent. of water, and termed *Verdet gris sec merchand*. The latter being of variable composition, and as buyers must have a definite product, it is the *Verdet gris extra sec* which is used in the preparation of the bouillie. It is sold as balls, cakes, or grains. To prepare the bouillie, it suffices to crush the verdigris, mix it with a little water, macerate itf or some days, and then dilute it to a suitable consistency.

**Properties.**—Verdigris is amorphous. But it swells in a little water after a few hours; forming a viscous paste beaten up with much water dibasic acetate of copper splits up into soluble copper acetate and insoluble cupric hydrate, which forms a blue flaky precipitate with the properties of Bordeaux bouillie. Bencker believes this precipitate remains flaky for a longer time, and thus keeps itself suspended longer than Bordeaux bouillie. The verdigris bouillie has the properties of Bordeaux bouillie and blue vitriol. The deposit of hydrated oxide of copper which it contains covers the leaf with a protective layer of insoluble copper oxide, and the solution of copper acetate acts like solutions of all soluble copper salts in an immediate and very energetic manner on the spores of fungi as well as on the plant itself. This soluble portion of the verdigris copper acetate would in fact produce burns if care were not taken to use sufficiently dilute bouillies. Now the dose of soluble copper acetate present in a verdigris bouillie is not sufficient in most cases to corrode the organs touched by spraying, and plants suffer comparatively little by this treatment. However, plants sensitive to dilute solutions of blue vitriol and to cupric hydrate deposited on the surface of their leaves will, after spraying with this bouillie, be poisoned to the same extent and suffer the same damage, followed by partial and even total fall of the leaves, as is the case with ordinary peaches and certain species of rose bushes. It has been found that the adherence of the cupric hydrate of the verdigris bouillie is superior to that of other bouillies. It must not be forgotten, however, that the cupric hydrates behave in the same manner in all bouillies if these are prepared and used rationally. If Bordeaux bouillie formerly adhered badly, compared with bouillies with a verdigris basis, it is not the case now with Bordeaux bouillie used immediately after its preparation. A neutral Bordeaux bouillie, a Bordeaux bouillie celeste, *eau celeste modifiée*, verdigris bouillie, and Perret's bouillie have many analogies to each other. Their adherence, so to speak, is the same, and their anticryptogamic energy almost identical. Careful study of this point has shown that the tendency of copper salts to poison plants as well as their anticryptogamic energy is perceptibly proportionate to their copper content. The action is inversely proportional to the molecular weight of the copper compound contained in a given amount of liquid, and the rapidity of the action is proportional to the degree of solubility of the copper compound. The weak acid or alkaline reaction of these preparations has no secondary curative effect. Verdigris bouillie must, therefore, be prepared with a weaker dose of verdigris than that of the blue vitriol, which enters into the composition of Bordeaux bouillie, first because blue vitriol only contains 25 per cent. of metallic copper, whilst verdigris contains 35 per cent.; secondly because verdigris is partially soluble in water. The dose of 1·5 per cent. is not exceeded in bouillies, it is mostly lower than this and descends to 0·1 per cent. Verdigris bouillie has the same drawback as blue vitriol and eau celeste. It leaves no visible mark on the plants, and renders the control of the work of the operator difficult. To obviate this drawback, Chuard and Porchet add potter's clay, china clay, carbonate of magnesia, gypsum, or chalk. It is, moreover, comparatively dearer than other copper preparations of equal copper content, which is an obstacle to its becoming popular.

**Use.**—Verdigris has been used as an anticryptogamic in France since 1890, and in America since 1892.

*Peronospora viticola,* de By. (mildew of the grape).—In virtue of the energy and adherence of verdigris, three treatments suffice (Bencker). The first fifteen days to three weeks after the issue of the first leaves with a 1·5 per cent. bouillie, 2 hectolitres per hectare (17·6 gallons per acre) suffice. If the invasion of mildew be very great, supplementary treatments with 0·35 per cent. of verdigris are required. Cuboni advocates this treatment.

*Guignardia Bidwelli*, V. and R. (black rot of grapes).—Galloway with six sprayings with 0·1 per cent. verdigris bouillie obtained 90·47 per cent. of sound grapes against 19·06 per cent. on untreated vines. According to experiments by Rathay and Havelka, the spores of *Guignardia* are killed after twenty minutes by steeping in 0·5 per cent. bouillie. Linhart got the same results with copper acetate. Rougier recommends Viala and Pacottet's bouillie consisting of neutral copper acetate 1 lb., acetic acid 8 fluid oz., water 10 gallons.

*Puccinia* (rust).—Galloway got interesting results by spraying a field of grain four times, on 6, 16, and 25 June, and 5 July; with a 0·3 per cent. bouillie he entirely prevented rust. The uredospores of *Puccinia coronata* were prevented from germinating by 1·0 per cent. bouillie.

*Entomosporium maculatum*, Lev. (leaf scald of the pear-tree).—Halsted found that 0·2 per cent. bouillie suffices to overcome this parasite, and Fairchild advocates verdigris as the best preparation against spots of the leaves of the pear-tree.

*Phytophthora infestans*, De By. (potato disease).—Whilst Pearson found verdigris as energetic as Bordeaux bouillie, Sturgis found it without action on *Phytophthora phaseoli* (Lima bean mildew).

*Rot of Grapes.*—Consecutive attacks of *Cochylis*. These are prevented, according to Vermorel, if the grapes are sprayed with verdigris.

**Copper Acetate,** $Cu(C_2H_3O_2)_2,H_2O$.—**Preparation.**—Neutral copper acetate, or crystallized verdigris, is obtained: (1) By treating copper turnings by acetic acid until complete solution is effected. (2) By double decomposition between blue vitriol and lead acetate.

$$\underset{\substack{\text{Copper}\\\text{sulphate.}}}{CuSO_4} + \underset{\text{Lead acetate.}}{Pb(C_2H_3O_2)_2} = \underset{\substack{\text{Copper}\\\text{acetate.}}}{Cu(C_2H_3O_2)_2} + \underset{\substack{\text{Lead}\\\text{sulphate.}}}{PbSO_4}$$

**Properties.**—Copper acetate forms greenish-blue crystals with a molecule of water of crystallization. These crystals contain 31 per cent. of metallic copper. They are completely soluble in five times their weight of boiling water at 15° C. Used to overcome cryptogamic diseases copper acetate behaves like blue vitriol, and in general, like all soluble copper salts, that is to say, it is poisonous to plants, whilst at the same time it acts very energetically on parasitic fungi. However, this action is ephemeral, because cupric acetate decomposes on the surface of the leaves into a basic acetate behaving like copper hydrate. Used in Italy at 1 per cent. against *Leaf Curl of Peach* it caused, like all other copper preparations, the total fall of the leaves and the fruit treated. A 0·5 per cent. solution of cupric acetate destroys the germinative power of the spores of *Guignardia Bidwelli* in twenty minutes, whilst 0·5 per cent. of blue vitriol takes thirty minutes to produce this effect. Its action on the spores of this fungi is therefore relatively identical with that of blue vitriol, for copper acetate contains 31 per cent. of metallic copper, whilst blue vitriol only contains 25 per cent. The action of copper acetate lasts longer than that of blue vitriol. Chuard and Duserre found that this was due to the neutral acetate being converted on the leaves into an insoluble, very adherent derivative.

**Use.**—Copper acetate has been used in Italy and Switzerland especially against mildew, *Peronospora viticola*, de By., in 0·5—0·8 per cent. doses. It is sometimes used in France in the last treatment of the vine, so as not to soil the grapes, and avoid introducing sulphuric acid into the wort or any other substance capable of changing the quality of the wine. Copper acetate is, so to speak, abandoned to-day and replaced by the copper bouillies in the struggle against parasitic fungi, for it has no advantage over the latter preparations and it is a little more costly in use.

**Perret's Bouillie** is a Bordeaux bouillie containing a portion of its hydrated oxide of copper in solution as cupric saccharate.

**Preparation.**—By mixing, in a certain order, a solution of blue vitriol and sugar with milk of lime. Perret, the inventor, prepares it as follows: Beat up 20 lb. of quicklime, after slaking with 80 gallons of water, and whilst stirring constantly add this milk of lime to 1 lb. of sugar in 10 gallons of water; then run this mixture of lime and saccharate of lime into a solution of 20 lb. of blue vitriol in 100 gallons of water. It is essential that the copper solution be cold. Prillieux advises that care be taken to see that the bouillie is slightly alkaline. Barth, in 1896, advised the preparation of cupric saccharate bouillie thus: Dissolve 20 lb. of blue vitriol in 40 gallons of water, and after cooling run in a solution of 3 lb. of sugar or 5 lb. of 50 per cent. molasses in 30 gallons of water, then a milk of lime with 1½ lb. of quicklime or 2 kilogrammes of slaked lime and 30 gallons of water. The necessary dose of sugar may also be added to the Bordeaux bouillie. The action of bouillies of this composition is excellent. Later on, the addition of more sugar was advocated. Peglion proposed ¾ lb. for 1½ lb. of blue vitriol and Petermann 4 lb. of molasses for 2 lb. of blue vitriol and 4 lb. of lime. The increase in the sugar must be regarded as injurious to the quality of the bouillie, and it throws discredit on a preparation which, after this change in its composition, lost the masterly qualities imparted to it by Perret and Barth. The amount of copper may be brought to the proportions now used in Bordeaux bouillie, say 0·5 —1 per cent. of blue vitriol, but the dose of sugar, which should never exceed 15 per cent. of the blue vitriol used, must also be reduced. Perret's bouillie is a bluish-green liquor with cupric hydrate and sulphate of lime in suspension. The sugar which enters into the bouillie prepared by Perret's and by Barth's processes is not enough to convert the whole of the blue vitriol used into saccharate. The 1—3 lb. added to the bouillie cannot convert more than 1·4—4·2 lb. of blue vitriol into saccharate. The saccharated bouillie contains, therefore, 0·14—0·42 per cent. of soluble copper. Perret remarked that by adding sugar to Bordeaux bouillie it became more adherent to the leaves than simple Bordeaux bouillie, and that its anticryptogamic action was increased owing to the soluble copper salts which it contained.

Barth was the most zealous advocate of this bouillie, which he regarded as the best, the ideal bouillie. It never burned the leaves, and its adherence was surprisingly perfect. This last property was due to the cupric saccharate being assimilated without injury by the plant, which would so far render it immune to cryptogamic diseases. This opinion has been greatly disputed. It has been shown besides that the plant had no need to absorb large amounts of soluble copper derivatives, but on the contrary, the strong doses absorbed after the use of soluble copper salts always injures the health of the plant. Infinitesimal doses of copper suffice to give to the plant greater resistance against parasitic fungi, and if that infinitesimal amount is not directly assimilable, it is rendered so by the juices transpired by the leaves. It is possible, however, that cupric saccharate, an organic derivative of copper, may be directly assimilable by the plant, and that this property may be such as to give it a plus value as a stimulating bouillie. This bouillie, however, cannot have a superior anticryptogamic action to other bouillies, for a bouillie can never act as a destructive agent of the organs of fungi which are distributed in the interior of plants. Its object is to damage the exterior organs of fructification, annihilate the spores, and prevent their dissemination. This end is perfectly attained by Bordeaux bouillie. Perret's bouillie was a great improvement on the primitive Bordeaux bouillie, when the latter had not the energy nor the adherence of the present bouillies, owing to defects in its composition. But Perret's bouillie now is perceptibly the same as Bordeaux bouillie, or such preparations as verdigris bouillies, which along with cupric hydrate contain a certain amount of soluble copper. Girard, agreeing with Gindt and Sendersens, regards Perret's bouillie as being more adherent. Other observers declare the contrary, but it has been generally observed that Perret's bouillie communicates a greener tint to the foliage and a more prolonged one than other bouillies. Galloway advocates adding to Burgundy bouillie a certain dose of sugar, and has used with success a mixture of blue vitriol 3 lb., soda crystals 3½ lb., molasses 3 lb. in 10 gallons of water. Whilst causing burns on the leaves of the vine this bouillie, used against black rot, brought the percentage of sound grapes from 46 per cent. on the untreated vines to 98·51 per cent. For a sucrated bouillie not to cause burns, the amounts of sugar indicated by Perret and by Barth should not be appreciably exceeded, for with larger doses of sugar the whole of the copper is transformed into soluble cupric saccharate which behaves like solutions of copper acetate. Bee-keepers have protested against the use of Perret's bouillie, under the pretext that bees by collecting copper scacharate on the surface of the treated leaves are poisoned, and may convey into the honey an element injurious to human health. It took long and careful experiments by E. Jacky to prove the want of foundation of their complaints, and to demonstrate that if bees are very fond of sugar and molasses, they shun and do not absorb these sweets when they contain copper.

**Use.**—After a general infatuation for Perret's bouillie, at the time when Michel Perret recommended it as a substitute for Bordeaux bouillie, which then possessed many defects, this preparation fell into oblivion. The chief reason, as pointed out by Dr. Cazeneuve, is that the composition of the Bordeaux bouillie has been so modified that as far as its action is concerned it cannot be compared with the primitive bouillie. By substituting molasses for sugar and by greatly increasing the dose, Perret's bouillie has been converted into a solution of cupric saccharate. As this bouillie contains large quantities of soluble copper, its contact with the plant becomes deadly to it. Its adherence is less and it does not stand rain. Perret's bouillie may be used in all cases where Bordeaux bouillie gives good results. However, Barth found it superior in the struggle against mildew. Nijpels found it better against *Phytophthora infestans*, de By., when applied in two sprayings annually. Sorauer prefers it against *Asteroma radiosum*, Fr., of the rose-bush and to prevent the fall of the leaves of this shrub, due to the parasiticism of a rust known as *Phragmidium subcorticum*, Wint.

Against *Alternaria brassicæ f. nigrescens*, Pegl. (roasting of the leaves of the melon) it is better than Bordeaux bouillie and it appears to act on *Botrytis cinerea*, Pers. [*Sclerotina Fuckeliana*, de By.] (grey rot of the vine).

**Various Bouillies.**—As soon as the active principle of the cupric bouillies was definitely established efforts were made to fix the cupric hydrate and copper carbonate which they contain in a more durable manner on the leaves. Everything which cements and binds was incorporated therein, milk, albumen, glue, soaps, oils, and resins. However, the action of these binders on copper derivatives is not, as may be supposed, purely mechanical. These substances often act chemically. Most of them form insoluble derivatives with copper, capable, it is true, if they are used immediately after their preparation, of depositing on the leaves a copper pellicle, a true varnish which will resist the weather indefinitely. But the thin pellicle which covers the leaf may in the end, as shown by Galloway, stop the physiological functions of the organs covered and injure the normal evolution of the plant; and these copper derivatives, insoluble in the atmospheric agents as well as in the exudation of plants, have lost, if not all, at least the greater part of their anticryptogamic power. Under such conditions they cannot, therefore, form like cupric hydrate an insuperable barrier to the spores deposited on the leaves. Parasitic fungi are very often seen to develop normally on leaves and fruit covered with a layer of these copper varnishes. The effect of the greater part of these new bouillies is, therefore, quite illusory. However, their quality depends greatly on their composition. When the amount of binders prescribed to render a bouillie adherent are not sufficient to convert the whole of the cupric hydrate into an insoluble binding organic derivative, that bouillie still contains the greater part of its copper under the active form of cupric hydrate which maintains its good anticryptogamic properties. The binders so used may encircle the active principles of the bouillie and retain them on the leaves and so become useful. Trials of comparative adherence made with bouillies normally anp freshly prepared, and thus at the moment when their adherence is at a maximum, have not always given results in favour of the new bouillies. The advantage of using binders in the bouillies may be regarded as problematical, for the simple bouillies now used show the same tenacity which may be regarded as sufficient. Still more than in the case of ordinary bouillies is it necessary to use these bouillies immediately after preparation, for the fine, flaky, organic precipitates which they contain in the beginning agglomerate and resinify, rapidly encrusting the machines and preventing a uniform distribution of the bouillie on the plants. Finally, the binders used in these bouillies may injure the organoleptic properties of the wine. It has been observed after their use that the wine left something to be desired, and the conviction was formed that it was these substances which passed into the wine and profoundly altered its gustative properties.

**Albuminous Bouillies.—Preparation.**—By adding to a solution of blue vitriol Bordeaux bouillie or Burgundy bouillie a sufficiency of an albuminous body to convert all the copper into copper albuminate.

**Lactocupric Bouillie** (Crouzel's).—**Preparation.**—Dissolve 20 lb. of blue vitriol in 10 gallons of water, add 4 gallons of unboiled milk, say about 1¼ lb. of casein, stir strongly for five minutes, and run into enough water to make 100 gallons. Skimmed milk does equally well.

**Properties.**—This bouillie is acid and forms a mixture of blue vitriol and cupric caseate; this latter forms a precipitate insoluble in water, the rôle of which is to retain by encircling them the small crystals of blue vitriol formed by the evaporation of the bouillies on the surface of the leaves. If burns caused by contact of blue vitriol with plants, especially with the proportions given above, be feared, it suffices to neutralize the acidity with copper carbonate. The bouillie thereby becomes an albuminous Burgundy bouillie, and contains a mixture of carbonate and caseate of copper. Crouzel regards the acid bouillie as the most active. Caseate of copper is comparatively stable and remains rather long suspended in the liquid as finely divided particles which do not choke up the machines, and can be perfectly distributed over the surface of the plant. Nevertheless, it is necessary to use this bouillie the moment it is prepared.

**Bordeaux Bouillie Modifiee.**—This name is applied to a bouillie to which a little skim milk has been added. Sorauer recommends it against *Uromyces Dianthi*, Niessel (poppy rust). Cazeneuve compared the adherence to the leaves of three albuminous bouillies, which he made thus :—

TABLE LVI.—*Composition in Grammes of Cupro-Albuminous Bouillies.*

| | I. | II. | III. |
|---|---|---|---|
| Blue vitriol | 2000 | 2000 | 2000 |
| Quicklime | 1000 | 1000 | 1000 |
| Milk, 2 litres, say casein | 60 | — | — |
| Dried white of egg | — | 100 | — |
| Dried blood | — | — | 100 |

The blue vitriol was dissolved in 70 litres of water, the lime slaked and beaten up with 20 litres of water and then run into the blue vitriol solution. The milk was diluted with 8 litres of water, and the solution of albumen and prepared blood in 10 litres of water; these solutions were finally run into the preceding mixture. The excess of lime was used to fix the casein and the albumen as caseate and albuminate of lime, and to preserve all its energy to the cupric hydrate of the bouillie. The sprayings were made on 16 August, 1897, some days before floods of rain, after which it was found that the adherence of the lactic Bordeaux bouillie was not appreciably better than that of the saccharated bouillie. But the spots produced by the evaporation of the albuminous bouillie lasted to the end of the season. Galloway added a very strong dose of glue to Burgundy bouillie. The composition of this bouillie was : Blue vitriol 3 lb., soda crystals 3½ lb., glue 3½ lb., water 100 gallons. Adherence was perfect, and the results obtained against black rot were : Untreated, 41·36 per cent. of sound grapes; treated with ordinary Bordeaux bouillie, 86·47 per cent.; treated with the new glue containing bouillie, 100 per cent. Unfortunately the cupric bouillie fixed on the whole surface of the plant so far injured the vegetation that Galloway cannot, in spite of the fine results obtained, recommend this new bouillie in preference to Burgundy bouillie.

**Soapy Bouillies.**—Attempts have been made to increase the adherence of different bouillies, and even of eau celeste by incorporating soap or oil. Copper salts form with fatty acids derivatives insoluble in water and cold alcohol, but soluble in ether and in amylic alcohol, and in ethylic alcohol in the hot state. To prepare a copper soap an ammoniacal solution of oil is added to an ammoniacal solution of copper hydrate. Neutralizing the excess of ammonia by acetic acid, an insoluble apple-green precipitate is obtained which agglomerates and resinifies quickly. The same compound is also formed, when a soap solution is added to ordinary copper preparations. Swingle was the first to add soap to copper bouillies in sufficient quantity to cause them to froth. He observed that these bouillies adhered even on very smooth leaves. Galloway, who experimented at the same time, recommended the following soapy Bordeaux bouillie : Blue vitriol 1 lb., quicklime ½ lb., soap 1 lb., in 10 gallons of water. He preferred rosin soaps to fatty soaps. The soap solution is added to the mixture of blue vitriol and lime, and the whole stirred until the froth persists. A soapy Burgundy bouillie of the following composition is also used in America : Blue vitriol 1¼ lb., soda crystals 1¾ lb., white soap ¼ lb., water 10 gallons. Having observed that the properties of eau celeste were actually increased by a little soap, and recognized that this new preparation is one of the best existing, Fairchild became the advocate of soapy eau celeste. When this bouillie is applied, it forms on the surface of the leaf by evaporation of the ammonia a precipitate of copper with the fatty acid of the soap, which owing to its sticky nature remains a long time adherent, and retains the cupric hydrate. Soapy eau celeste is no longer in this form so corrosive to plants, and does not attack the leaves of fruit trees, vine trees excepted. In America it is prepared as follows : Dissolve 400 grammes of blue vitriol in 50 litres of water, add thereto 20 cubic centimetres of ammonia of 26° Bé., and finally a solution of 1·25 kilogrammes of soap in 50 litres of water. In Italy a more ammoniacal eau celeste is used, the composition of which is as follows : Blue vitriol ½ lb., ammonia 16—25 fluid oz., soap 3 lb., in 10 gallons of water. According to Tozetti and Del Quercio, this eau celeste may be used more dilute. In France, Lavergue, Guillon, and Gouirand are the champions of soapy bouillies. They compared a soapy bouillie with the usual bouillies, and classified them as regards adherence thus: (A) *Soapy* bouillie made from 2 per cent. blue vitriol and 3 per cent. of soap. (B) *Bicarbonate of copper* bouillie made from 2 per cent. blue vitriol and 3 per cent. of bicarbonate of soda. (C) *Copper carbonate* bouillie made from 2 per cent. blue vitriol and 3 per cent. of sodium carbonate. (D) Bordeaux bouillie made from 2 per cent. blue vitriol and lime to alkaline reaction. Eau celeste made from 2 per cent. blue vitriol and ammonia to complete solution. *Verdigris* containing 2 per cent. verdigris. (E) *Gelatinous* bouillie. Bordeaux bouillie with 3 per cent. gelatine. (F) *Saccharated* bouillie, above bouillie with 1 per cent. molasses. (G) Neutral bouillie containing 2 per cent. of neutral acetate of copper.

Soapy bouillies being even more injured by keeping than Burgundy bouillie, all the above-mentioned bouillies were applied immediately after preparation. An old soapy bouillie encrusts the spraying machines. Condeminal advises a Bordeaux bouillie to which linseed oil has been added. This plays no other part than the soap used in soapy bouillie. This bouillie is prepared as follows: Slake 10 lb. of recently burnt fat lime and emulsify therewith ¼ lb. of linseed oil, then run this mixture into a solution of 20 lb. of blue vitriol in 50 gallons of water, and make up the bulk with enough water to make 100 gallons. To render these bouillies insecticidal as well as anticryptogamic, petroleum is added. A stable bouillie is prepared as follows: To a soapy Bordeaux bouillie of the following composition, blue vitriol 1 lb., lime ½ lb., soft soap 1—3 lb. or rosin soap 7—9 lb., in 10 gallons of water, add 2—6 per cent. of a petroleum and soap emulsion, made from petroleum 2 gallons, soap 1¼ lb., water 1 gallon. Zacharewitsch obtained excellent results with a petroleum and soap bouillie against *Fumago salicina* and the *Cycloconium oleaginum* (fumagine of the olive-tree) which invade the olive attacked by *Lecanium oleæ*. The bouillie contained: Soft soap 10 lb., petroleum 4 gallons, blue vitriol 10 lb., in 100 gallons of water.

A concentrated solution of precipitated green copper soap in ether or alcohol applied by the brush on the wounds of trees produced by the woolly aphis covers them after drying with so adherent a cupric pellicle that it forms a very efficacious and durable protection against exterior destructive agents, and lets the wounds heal rapidly. Rain does not remove this coating, which thus persists for many years. Laborde found that Saglio bouillie, containing 3 per cent. of a mixture of rosin soap and blue vitriol, used in the struggle against the *Eudemis*[1] and *Cochylis* of the vine, destroys 95 per cent. of the first and 80 per cent. of the second parasite.

**Resinous Bouillie.**—On the suggestion of Rosenstiel, Perraud recommended in 1898 a resinous bouillie of the following composition: Blue vitriol 1—2 lb., rosin ½ lb., soda crystals to alkaline reaction, in 10 gallons of water. The preparation requires some precautions, for rosin does not dissolve in water, only in hot alkali; 5 lb. of carbonate of soda are dissolved in 2 gallons of water, then, after having brought this solution to the boil, 5 lb. of powdered rosin are added gradually, stirring the mixture till it becomes fluid. This solution of rosin soap is poured after cooling into a solution of 20 lb. of blue vitriol. A solution of carbonate of soda is added to this mixture until the bouillie is alkaline to litmus paper and the bulk made up to 100 gallons. This bouillie much resembles the soapy Bordeaux bouillie recommended in 1895 by Galloway, made by adding rosin soap to a 1 per cent. Bordeaux bouillie. In this same category may be classed the Aleppo pine galipot bouillie, recommended by André and Trabut referred to on p. 224.

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[1] Eudemis (tortrix of the grape). *Eudemis Botrana.*—This small moth has the same habits and causes the same damage as the *Cochylis*, but it has three generations a year and thus attacks the inflorescence, the sour grapes (verjus), and the ripe grapes. The greenish caterpillar reaches 1 centimetre.

Vidal recommends against the fumagine *Capnodium* (black smut) of the olive-tree a bouillie consisting of Bordeaux bouillie 100 gallons, spirits of turpentine 1 gallon.

# CHAPTER XVII

## MERCURIC CHLORIDE (CORROSIVE SUBLIMATE)—TIN CRYSTALS

**Mercuric Chloride (Corrosive Sublimate),** $HgCl_2$.—**Preparation.**—By [dry] heating an intimate mixture of equal parts of mercuric sulphate and common salt to which a little manganese dioxide has been added.

**Properties.**—White crystalline powder of which 6·57 grammes are soluble in 100 grammes of water at 10° C., and 53·96 grammes in 100 grammes of water at 100° C. It is slightly soluble in alcohol and very soluble in ether, which extracts it even from its aqueous solutions. The taste of corrosive sublimate is bitter and nauseous. It is a violent poison, which absorbed by the mouth produces considerable inflammation of the mucous membrane, even to the point of destroying it. Corrosive sublimate possesses the property of precipitating albumen; it forms with it mercuric compounds soluble in an excess of albumen and in solutions of common salt. Its powerful antiseptic action results from this affinity for albumen. Corrosive sublimate preparations should be made in glass or earthenware dishes, the metals decomposing it.

**Action of Corrosive Sublimate on Plants.**—Mercuric chloride acts on plants like blue and green vitriols, but proportionately with greater intensity. If the plant is placed through the roots in contact with a certain dose of corrosive sublimate, it dies. Mouillefert found that this dose for vines planted in 3-litre pots was 2 grammes in 250 cubic centimetres of water; the dose of 0·5 gramme in 250 cubic centimetres of water had no effect on the vine but killed weeds, chiefly *Mercurialis annua*, *Senecio vulgaris*, *Sonchus oleratus*, *Borrago officinalis*, *Sinapis arvensis*, *Malva sylvestris*, and *Amarantus blitum*. Trials by Mouillefert to overcome the phylloxera show that corrosive sublimate solutions are absorbed by the roots and poison the juice. Spraying with corrosive sublimate solutions burns the leaves; however, a solution of 0·015 per cent. does not injure orange-tree leaves (Coquillet). Mercurial sprayings are deadly to the vine (Leon Vignon and J. Perraud). Dr. Cazeneuve's trials, however, tend to show that corrosive sublimate used in 0·04—0·05 per cent. does not hinder the growth of the vine. Like green and blue vitriols an infinitesimal dose of sublimate may stimulate vegetation instead of injuring it. Ono has shown that this dose is 0·0013 per cent. for green algæ possessing chlorophyll. The pickling of the seed in a 1—2 per cent. bath of corrosive sublimate does not diminish their germinative power. Sturgis found that the seeds of the cotton plant germinate after steeping half an hour in a 1—2 per cent. solution of sublimate.

**Action on Fungi and their Spores.**—Used in a dose lower than 0·0013 per cent. corrosive sublimate stimulates, according to trials by Ono, the growth of saprophytic fungi, but at this strength parasitic fungi cannot support it. Hitchcock and Carleton found that the uredospores of *Puccinia coronata* and *Puccinia rubigo vera*, which are the spores of the parasitic fungi most resistant to poisonous salts, were incapable of germinating in a 0·001 solution of corrosive sublimate. There is, according to Wuthrich, a great similarity between the action of corrosive sublimate on the spores of fungi and that of blue and green vitriol. This action is, on the one hand, proportional to the chemical equivalent of these salts, and on the other hand, these proportions adhered to, corrosive sublimate is ten times stronger than blue vitriol and 100 times stronger than green vitriol. The following are the respective doses of these salts required to prevent the germination of the different parasitic fungi :—

TABLE LVII.—*Showing the Dose of Green and of Blue Vitriol and of Corrosive Sublimate Per Cent. Required to Prevent the Germination of the Spores of Different Parasitic Fungi.*

| Fungi. | Spores. | Germination nil. | | |
|---|---|---|---|---|
| | | Green vitriol. | Blue vitriol. | Mercuric chloride. |
| *Phytophthora infestans* . | Conidia. | 0·139 | 0·0125 | 0·00135 |
| ,, ,, . | Zoospores. | 0·139 | 0·0125 | 0·00135 |
| *Peronospora viticola* . | Conidia | 0·139 | 0·0125 | 0·00135 |
| ,, ,, . | Zoospores | 0·139 | 0·0125 | 0·00135 |
| *Puccinia graminis* . . | Uredospores. | 1·39 | 0·125 | 0·00135 |
| ,, ,, . . | Aecidiospores. | 0·139 | 0·0125 | 0·00135 |
| *Ustilago carbo* . . | Spores. | 1·39 | 0·125 | 0·00135 |
| *Claviceps purpurea* . . | Spores. | 13·9 | 0·0125 | 0·00135 |

Herzberg submitted the spores of different species of *Ustilago* to the action of corrosive sublimate and found that they all behave in much the same way, with the exception of *Ustilago Jenseni*, which resists a little better. The following are the doses which prevent the germination of the spores examined :—

TABLE LVIII.—*Showing the Dose of Corrosive Sublimate Per Cent. Required to Prevent the Germination of Spores of the Various Species of Ustilago.*

| | Old spores. | Young spores. |
|---|---|---|
| *Ustilago Jenseni* . . | 0·005–0·01 | 0·005–0·01 |
| ,, *Avennæ* . . | 0·005–0·01 | 0·001–0·005 |
| ,, *Perennans* . | 0·001–0·005 | 0·001–0·005 |
| ,, *Hordei* . . | 0·005–0·01 | 0·001–0·005 |
| ,, *Tritici* . . | 0·005–0·01 | 0·001–0·005 |

**Action of Corrosive Sublimate on Insects.**—Contact with corrosive sublimate, even prolonged, has no action on insects and their eggs; thus the eggs of *Bombyx mori* still hatch after twenty-four hours steeping in a 1 per cent. solution. Sublimate is, however, a violent poison; it may enter with the food of the insect into their digestive system.

**Use.**—*Potato Scab*, produced by bacteria, Bolley; *Potato Pox* (*Rhizoctinia Solani*), Kuhn; *Rot of the Stem of the Potato* (*Rhizoctinia*), Rolfs.—Bolley found that corrosive sublimate is one of the best substances to disinfect seed potatoes and safely destroy all the bacteria and spores of parasitic fungi on the surface of these tubers. The results obtained controlled by Sturgis, Rolfs, and Woods were excellent. This method, in fact, gave 99 per cent. of healthy potatoes, whilst the infected potatoes (the untreated) only gave 1 –4 per cent., and the tubers treated by Bordeaux bouillie, 53 –57 per cent. But the effect of this treatment, like that of the others already described, is *nil* if the potatoes are planted in a field already infected and manured with infected dung. The soil should be disinfected previously, or laid down to a different crop for several years. Potatoes are disinfected thus: They are freed from earth and the pellicular membranes surrounding them, then steeped for 1½ hours in a 3 per cent. solution of corrosive sublimate. They are then washed, dried for a day, and then planted. Rolfs uses a 0·94 per cent. solution. Jones and Morse advise disinfection by immersion for one hour in a 1 per cent. steep of corrosive sublimate. Germination is normal even after steeping five hours; after twenty-four hours a certain injury occurs to the germinative capacity.

*Bacillus tabificans*, Dell.—A bacillus which invades the leaves of the beet and produces jaundice. Delacroix found this bacillus on the seed and obtained sure disinfection by steeping the seeds in a 2 per cent. solution of sublimate.

*Peronospora viticola*, de By. (mildew of the vine).—Corrosive sublimate is, without doubt, a powerful anticryptogamic, which, in the struggle against cryptogamic diseases of the vine, in general, might be of great service if it were not so poisonous, and if it adhered better. Cazeneuve in his trials with a mixture of excelsior verdigris 1 per cent., and of corrosive sublimate 0·04 per cent., and with a solution of mercuric chloride of 0·05 per cent., did not find in the first case any greater categoric action than verdigris alone, but in the second case the action was perfect. On the other hand, Kaserer obtained a perfect result by the use of a solution containing 0·1 –0·2 per cent. of sublimate and milk of lime. The adherence of the sublimate being very bad, it is necessary to multiply the treatments according to the frequency of the rains if efficient protection of the plant be desired. An addition of 0·5 per cent. of starch has been tried to increase the adherence of sublimate solutions. Corrosive sublimate is a very dangerous substance to man, and there is no doubt that it can eventually pass, although in small amount, from the grapes into the vine. Leon Vignon and J. Perraud have estimated the mercury in drawn wine, pressed wine, lees marc, and grapes from vines treated with mercury salts. It follows from their analyses that grapes and the products of their fermentation only contain traces of mercury, without danger to the consumer. Berthelot followed this note, presented to the Academy of Sciences, by the following remarks: "The effects of the doses of mercury found by the above authors on products consumed daily and in a prolonged manner ought to be regarded as suspicious and dangerous." It is thus prudent and reasonable only to apply the mercurial treatment on such organs of plants as are not consumed, or in winter applications.

*Phytophthora infestans*, de By. (potato disease).—This disease has been circumscribed by adding corrosive sublimate to the soil. This treatment is, however, too costly.

*Ustilagineæ* (smut diseases).—Bolley found that the disinfection of seed-corn against *Ustilago Bordeih*, Pers., by corrosive sublimate gave superior results to that done with blue vitriol, formaline, hot water, or potassium sulphide.

*Uredineæ* (rusts).—Sublimate has been used preventively against the rust of cereals. This substance, however, has given poorer results than blue vitriol: a 0·1 per cent. solution has little effect, a 0·01 per cent. solution is without action.

*Fusarium roseum.*—Mangin advises to overcome this disease by disinfecting the soil with corrosive sublimate.

*Guignardia Bidwelli*, V. and R. (black rot of grapes).—The action of corrosive sublimate on the spores of fungi has been compared with that of blue vitriol, and, as has been shown, it is ten times stronger. Some vine-growers have used sublimate in place of cupric bouillies in the treatment of black rot. Cazaux and Quentin declare they have obtained decisive results very superior to those obtained by cupric bouillies. The latter obtained a perfect result on a portion of a vineyard, on a low, wet situation, favourable to the development of cryptogamic diseases, and whose crop it had never been possible to preserve entirely; it even stopped an invasion of black rot in full evolution on the grapes. These vines were treated with four sprayings with a 2 per cent. Bordeaux bouillie containing 1 per cent. of sublimate. The plots treated with pure Bordeaux bouillie did not nearly give so good a crop as those treated with the sublimate bouillie. The winter treatment, consisting in coating the stems with a solution of sublimate, is greatly recommended against this formidable disease.

**Disinfection of Flower Seeds.**—Hiltner advises steeping for two hours in a 0·1 –0·2 per cent. solution to disinfect flower seed from plantations invaded by this redoubtable fungus, or purchased from outside. This treatment does not injure the germinative capacity of the seed, even if the steeping lasts eight hours.

**Use against Insects.**—*Cochylis ambignella*, Hubn. (cochylis of the vine), *Tortrix vitana* (pyralis of the vine).—Barbut tried with mediocre success solutions of corrosive sublimate to destroy caterpillars of butterflies. It has been remarked, however, that vines treated against cryptogamic diseases by mercurial bouillies no longer suffer from these caterpillars.

*Aspidiotus aurantis* (coccis of the orange-tree).—Destroyed by spraying trunks and branches with a strong solution of corrosive sublimate.

*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—Mouillefert showed that it took four hours' contact in a 1 per cent. solution to kill this formidable aphis. The oldest insects succumb first, the youngest last. By dipping the extremity of a root covered with adult and young phylloxera into a solution of sublimate, the adults, the sucking proboscis (rostulum) of which sunk in the root continually pumps the juice, die in an hour, whilst the larvæ persist. Used on an infested vine the results were bad. Vines stripped to a depth of 15 centimetres (6 inches) were treated with 20 grammes of mercuric chloride dissolved in 10 litres of water. After a few days the roots examined still contained numerous living phylloxeras. Corrosive sublimate is therefore powerless against this insect, for the physical and chemical forces to which this salt is subjected in the soil soon render it harmless. The same failure attended the attempt to poison the sap by introducing into it 1 gramme of calomel (mercury protochloride) in a hole, made at the base of the stock, which was closed up forthwith. Neither had mercury bisulphide (Catala's process) any action on this aphis.

*Schizoneura lanigera* (woolly aphis).—The use of corrosive sublimate sprayings in concentrated solution does not destroy this aphis. Thiel found, however, that an insecticide consisting of mercurial ointment 1 lb., soft soap 7 lb., petroleum 2 lb., to which alcohol is added at the moment of use, is one of the most active compositions capable of killing all the aphides and of radically curing the apple-trees.

*Phorbia brassicæ.*—Tests with mercury bichloride 1 : 1,000 have been made against the cabbage root maggot with satisfactory results in Pennsylvania.

*Wood-boring insects.*—To prevent these from damaging timber in Australia mercury bichloride dissolved in methylated spirits (0·2 per cent. solution) is successully employed.

*Ants.*—Corrosive sublimate is used to poison the bait.

*Rodents.*—To kill rats, balls are made from a paste of bread-crumbs 12½ oz., butter 6 oz., sublimate or nitrate of mercury 3 oz., placed at the spot frequented by the rodents.

**Tin Crystals,** $SnCl_2$.—**Preparation.**—By dissolving tin in concentrated hydrochloric acid, taking care there is an excess of tin. The liquid heated until it marks 75° Bé. deposits on cooling the product known as tin crystals.

**Properties.**—Stannous chloride is very soluble in water. If the solution be diluted it becomes cloudy, depositing an oxychloride, $SnCl_2SnO$; tin crystals are poisonous.

**Use.**—Sbrozzi tried tin crystals as a substitute for blue vitriol to overcome *Peronospora viticola*, de By. (mildew of the vine).—He found it was very inferior to blue vitriol and incapable of replacing it.

# CHAPTER XVIII

## DERIVATIVES OF CARBON (CARBON COMPOUNDS)—PRODUCTS DERIVED FROM THE FATTY SERIES—PETROLEUM (BURNING OIL)—PETROLEUM SPRAYS—PETROLEUM OIL EMULSIONS—PETROLEUM-SOAP EMULSIONS—PETROLEUM SPIRIT—PETROLEUM JELLY—ACETYLENE

**Petroleum.—Natural Occurrence.**—Petroleum is a natural mixture of all the formenic hydrocarbides.[1] They are found together in these mineral oils from butane, even from ethane and propane to hexadecane. All these hydrocarbides are normal in structure without lateral chains, as $C_nH_{2n+2}$. But the composition of these petroleums is not everywhere the same. American petroleums contain, besides saturated hydrocarbons of the formulæ $C_nH_{2n\;2}$, some non-saturated hydrocarbons of the series $C_nH_{2n}$, as well as a little cumene and mesitylene. Caucasian petroleum consists of polymethylenic hydrocarbons. Petroleum forms large subterranean deposits which constitute naphtha (crude oil) and which are tapped by means of wells.

**Commercial Products.**—In the industry the petroleums are separated by [fractional] distillation and classed according to their volatility thus:—

1. *Petroleum Ethers.*—Hydrocarbons, b. p. 0—70° C.; D = 0·600—0·650. Consist especially of pentane and hexane.
2. Petroleum spirit (commercial ligroin), b. p. 70—120° C.; D = 0·650—0·720. Consist especially of heptane and octane.
3. Petroleum oil (burning oil, photogene), b. p. 120—280° C.; D = 0·750—0·820.
4. Heavy petroleum oils, b. p. 280—380° C.; D = 0·820—0·870.
5. Crude paraffin wax (paraffin scale), m. p. 30—65° C.; b. p. 170—254° C.; D = 0·900—0·950 from $C_{17}H_{36}$ to $C_{25}H_{52}$.
6. Petroleum jelly, unctuous, inodorous, unoxidizable grease, m. p. 30—40° C.; obtained by distillation of petroleum so long as it yields volatile compounds, then by oxidizing the residue in the open, and filtering through animal charcoal.

**Petroleum Oil or Burning Oil.**—Petroleum oil or burning oil is that fraction from crude petroleum which is most used against insects which ravage plants. It is used as such, or in different emulsions.

**Action of Petroleum on Plants.**—Petroleum is very injurious to plants. Spraying with petroleum emulsions is almost always prejudicial to the leaves and tender branches. The poisonous capacity of petroleums of different compositions differ. The sensibility of different plants also varies; whilst the cabbage stands a 5 per cent.

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[1] *Translator's Note.*—Known to us as the marsh gas or paraffin series, but to the disciples of Berthelot as the formenic hydrocarbides.

emulsion, the vine only bears 2·5 per cent., and even that injures the *Cucurbitaceæ.* The action of emulsions depends greatly on their preparation; perfect emulsions diffused through much water do not separate drops of petroleum, that is to say, which do not split up have a comparatively harmless action on the leaves of plants, whilst badly prepared emulsions, allowing the petroleum to aggregate on the same point, are in equal doses very injurious. In using petroleum to destroy insects only perfect emulsions must be used. The prolonged contact of petroleum on the trunk of a tree may become deadly and must be avoided. The trunk and the branches coated, even in winter, absorb sufficient quantities of petroleum, which if they do not cause the death of the tree, at least so far disturb its economy as to retard the opening of the buds in the spring. Roots are likewise very sensitive, and the absorption of petroleum through them causes the death of the plant; 20 cubic centimetres of petroleum spread in 4 litres of soil kill the vine, haricots, and weeds, such as *Senecio* and *Sonchus.* A soil drenched with petroleum is no longer fertile, until the petroleum is evaporated, but then there is produced, as after treatment with carbon disulphide, a more intense vegetation resulting from the perfect disinfection of the soil by petroleum vapours. Withelm recommends steeping seed which it is desired to protect against insects sixteen to twenty-four hours in pure petroleum. This prolonged contact only slightly lowers the germinative capacity of the seed.

**Action of Petroleum on Insects.**—Petroleum acts on insects by contact, and by its asphyxiating vapours. Contact with pure petroleum causes the immediate death of all insects it is capable of penetrating, even those with the hardest shells, which protects them from the insecticides in aqueous solution. As an emulsion, petroleum is less energetic; eggs especially resist emulsions containing up to 30—35 per cent. of petroleum, whilst 2·5—6 per cent. emulsions kill all soft-skinned insects. The poisonous action of petroleum vapour never manifests itself in the open air, only in a closed vessel, or in the soil. In a closed vessel, Mouillefert destroyed the phylloxera by placing a contaminated root for two days in a 2 litre vessel containing at the bottom 5 cubic centimetres of petroleum. In the soil the injurious action does not occur, except at a short distance from the spot where the petroleum has been injected. From this point of view, petroleum is inferior to carbon disulphide and cannot replace it.

**Use.**—Burning oil has found the most varied applications in the struggle against injurious insects, and its use is particularly general in America, where it is the best-known insecticide. It is used sometimes in the pure state, but generally in a state of emulsion with different substances capable of mechanically dividing it.

**Use of Petroleum in the Pure State.**—The action of petroleum on insects is radical and infallible; efforts have therefore been made to use it preferably in this form, so as to free it definitely from dangerous parasites, when there is no risk of destroying the plants treated at the same time. If it did not possess such a poisonous action on the plant it would be perfect. Unfortunately, the plant does not without special precaution stand contact with pure petroleum, and in spring or summer this method should only be used in exceptional circumstances. On the other hand, it is not dangerous to plants during the winter sleep, or as an injection in the soil some time before planting.

Marlatt recommends its use as a spray or sponge wash in winter on the aged part of trees for the total destruction of *Kermes* and *Scolytes*. But it was especially recommended by Webster for the destruction of *Aspidiotus* and *Lecanium* of fruit trees. Webster submitted his observations and his processes to the Congress of American Phytopathologists in 1896. Smith and Alvood write thus on the use of petroleum :—

" *Petroleum sprays* may be used with impunity on all fruit trees, even in full vegetation, by taking the following precautions. (If these precautions be neglected there will be a loss of 90 per cent. of the trees treated) :—1. Spraying should be done with an apparatus capable of reducing this liquid into a fine fog, capable of touching the whole surface of the plant without really moistening it. The formation of drops, which might flow along the trunk to the roots, must be avoided. Poisoning always occurs when the roots are drenched with petroleum. 2. The operation must be conducted in warm, dry weather, for the petroleum should evaporate forthwith so as not to kill the plant. 3. It is necessary to operate from March to September. In single treatments September is the month chosen. 4. *Burning oil* (lamp oil) must be used and not crude petroleum, which contains insufficiently volatile ingredients. 5. It is well to cover the fruit buds before spraying. In these conditions peach-trees and plum-trees are more sensitive than apple-trees and pear-trees. The trees treated have finer shoots, but the treatment appreciably diminishes the crop."

The report of the Tenth Congress of the American Entomologists in 1898 is less enthusiastic on the use of pure petroleum. It concluded, after discussion, that pure petroleum is a highly dangerous insecticide for trees, but which may be unhesitatingly used when it is a case of the destruction of insects as formidable as the San José louse (*Aspidiotus perniciosus*) and certain kermes. In this case it must only be used on the old wood, and in dry, warm weather, in which it evaporates forthwith.

*Solenopsis geminata*, F., is the chief protector of various Coccids, and when thus fostered, *Pseudococcus citri*, Risso, the principal pest of pineapple in Porto Rico, may become very abundant. Both the ant and the mealy-bug may be checked by a spray of 2 gallons of kerosene, 1 pint of crude carbolic acid, ½ lb. of soap and 1 gallon of water.

*Ocneria dispar*, Sch. (gypsy moth).—Petroleum is more active than the tar generally used for the destruction of the eggs of this injurious butterfly. The destruction of the eggs is complete; a jet apparatus is used to localize the action of the pure petroleum on the aggregation of eggs alone.

*Cossus ligniperda* (*Cossus gâte-bois*) (goat moth).—Introduce petroleum into the tunnels dug in the trunk of trees and plug with mastic (Truelle).

*Vespa* (*Guepe*) (wasp) and *Formica* (*Fourmi*) (ants).—Pure petroleum is greatly recommended for the destruction of wasps' nests underground. Early in the morning, before the exit of the wasps, about a glass of petroleum spirit is run into the nest through the aperture, then the aperture is plugged, first with a pad drenched with petroleum, then with earth so as to prevent the vapours of petroleum from escaping. Carbon disulphide is, however, better then petroleum spirit.

*Schizoneura lanigera*, H. (woolly aphis).—Amongst the eighty-one methods recommended in 1903 to destroy this aphis, Thiele found that only pure petroleum, petroleum emulsion with soft soap, the alcoholic solution of corrosive sublimate, carbon disulphide, amylic alcohol, tar, and a mastic of lime and cow-dung, were capable of entirely destroying it. All the other methods had only a temporary effect.

*Phylloxera vastatrix* (phylloxera of the vine).—Mouillefert found that petroleum had an immediate action on this aphis, but that its vapours alone acted slowly. Used to overcome the phylloxera on vines in pots the results were excellent, but there was complete loss on vines on the large scale. The aphis still lived on stocks which received up to 150 cubic centimetres of petroleum. Petroleum is thus much less energetic than carbon disulphide, for its diffusion through the soil is bad, so that it cannot act at a great distance from the spot where it was injected. The coating of the roots was rejected as too dangerous to the health of the vine by the commission to investigate the different processes recommended to overcome the phylloxera. It would appear, however, that the disinfection of the vine by petroleum is possible by steeping the roots of uplifted stocks in a bucket filled with crude petroleum; the stocks replanted in a soil disinfected with petroleum yield vines the health of which is perfect and the roots of which show no more phylloxera.

*Melolantha vulgaris* (cockchafer).—The diffusion of petroleum through the soil is recognized as insufficient to destroy injurious insects or their larvæ beyond a very narrow zone round the hole into which petroleum was injected; it was, however, found that the vapours are disagreeable to the insects, and that these desert a field smelling of petroleum. Dorning and Decaux utilized this property to free fields, not only of white-worms, larvæ of the cockchafer, but also grey-worms, caterpillars of the common dart moth, the larvæ of wire-worms, the nematodes, and the larvæ of the beet carrion beetle. It suffices at the time of tilling the ground to bury rags steeped in oil and petroleum from the factories rather deeply underground.

*Gryllotalpa vulgaris* (mole cricket).—Gemadius advises to destroy the grasshopper by running petroleum into the tunnels which it bores in the ground. A 25 per cent. emulsion of petroleum is as effective as pure petroleum.

*Leucotermes flavipes* is becoming more and more destructive in the north central United States. Where the tunnels of the termites can be detected, a small hole should be drilled in the wood and a quantity of kerosene injected. It is important that the fumes should reach the nests, and every effort should be made to locate them. A few ounces of pyrethrum added to each gallon of kerosene increases its action.

*Culex pipiens* (common gnat).—Two grammes of petroleum per acre suffice to form on the surface of stagnant water a pellicular layer which kills the gnats which live in the water. The larvæ of the common gnat being amongst the number, it is easy to get rid of them.

*Lepus europæus*, L. (hare); *Lepus cuniculus* (rabbit).—Taschenberg points out the fact that trees treated by petroleum are respected by hares and rabbits, and Hofer advises simply to stretch a cord steeped in petroleum around the fields and gardens which it is desired to protect from these rodents.

**Use of Petroleum as Emulsions.**—Petroleum is divided mechanically into infinitely small particles by mixing it mechanically with finely divided solid substances, sand, earth, or with liquids, aqueous solutions, milk, or oil. The concentration and the composition of the emulsions vary greatly. Comparatively with pure petroleum a well-prepared petroleum emulsion, that is to say, homogeneous, behaves in its effects on plants and insects like a dilute solution. According to the concentration of the emulsion its capacity for injuring the plant as well as its insecticidal properties will be diminished or increased.

A report issued by the U.S. Department of Agriculture says:—Experiments have demonstrated that grubs may be killed by spraying the trees and branches with a strong solution of kerosene emulsion. This should be done not earlier than November and not later than March, because this spraying when the trees are in leaf will destroy the foliage and check growth. The emulsion may be prepared as follows: Kerosene emulsion (soap formula), kerosene, 2 gallons; whale oil soap (or one quart soft soap), one-half pound; water, 1 gallon. The soap, first finely divided, is dissolved in the water by boiling and immediately added boiling hot, away from the fire, to the kerosene. The whole mixture is then agitated violently while hot by being pumped back upon itself with a force pump and direct discharge nozzle throwing a strong stream, preferably one-eighth inch in diameter. After from three or five minutes' pumping the emulsion should be perfect and the mixture will have increased from one-third to one-half in bulk and assumed the consistency of cream. Well-made emulsion will keep indefinitely, and should be diluted only as wanted for use. For the treatment of large orchards or in municipal work requiring large quantities of the emulsion, it will be advisable to manufacture it with the aid of a steam or gasoline engine, as has been very successfully and economically done in several instances, all the work of heating, churning, etc., being accomplished by this means. The use of whale oil soap, especially if the emulsion is to be kept for any length of time, is strongly recommended, not only because the soap possesses considerable insecticide value itself, but because the emulsion made with it is more permanent, does not lose its creamy consistency, and is always easily diluted, whereas with most of the other common soaps the mixture becomes cheesy after a few days and needs reheating to mix with water. Soft soap answers very well, and one quart of it may be taken in lieu of the hard soaps. In limestone regions or where the water is very hard, some of the soap will combine with the lime or magnesia in the water, and more or less of the oil will be freed, especially when the emulsion is diluted. Before use, such water should be broken with lye, or rain water employed. For use on locust trees dilute 1 gallon of emulsion with 2 gallons of soft water. Pure kerosene and pure petroleum will effectively kill the insects, but may do some damage to the bark of the trees. The Insecticide and Fungicide Board of the Department of Agriculture, U.S., has called attention to the fact that kerosene emulsions made by certain manufacturers cause serious injury to the foliage of various plants when used as a summer spray at the dilutions recommended on the label by the manufacturers. A study of this question has convinced the Department that some manufacturers are not preparing their kerosene emulsions correctly, so that when they are mixed with water the oil separates out and the products therefore burn vegetation, which they would not burn if the emulsions were correctly prepared. The Board also finds some indications that some manufacturers are using in their kerosene emulsions certain fractions of petroleum which are quite different from kerosene and are perhaps the cause of this excessive burning.

Another U.S. Government bulletin states that good oil sprays are cheaper than lime-sulphur and give better control for most insect pests of fruit. They are made from either miscible oils or emulsion stocks. A miscible oil is an oil solution of an emulsifier. An emulsion stock is a concentrated emulsion, containing oil, emulsifier and water. Miscible oils require more care in dilution, the first water must be slowly added and thoroughly worked in. For dormant spraying, the best results in 1924 were obtained with the so-called neutral type of lubricating oil; heavier oils apparently lack penetration, and lighter oils have not body enough. Used crank-case oil was tried, but is too uncertain in composition to be dependable. The best emulsifier for miscible oil is cresoap, which is used in the proportion of 10 per cent. by weight (or 9 per cent. by volume) to 90 per cent. weight (or 91 per cent. volume) of lubricating oil. It is made by dissolving 5 parts by volume (or 5½ by weight) of potash fish-oil soap, 4 parts by volume (or 4½ by weight) of cresol (crude cresylic acid 97—99 per cent.). The soap should contain no free alkali and should have 30 per cent. of moisture. When the soap is mixed with the cresol, the emulsifier becomes fluid and will dissolve at once in the oil. Soda or weak potash soap should not be substituted for the potash fish-oil soap. This formula constitutes, the most concentrated miscible oil, and 4¼ gallons of the stock are needed to make 100 gallons of 4 per cent. spray. This stock requires no boiling or pumping and does not freeze or spoil on standing; its increased efficiency more than compensates for its greater cost. Where water is very hard this miscible oil is not recommended; a non-soap spray should then be used. The best non-soap emulsifiers for emulsion stocks are calcium caseinate spreader and glue. These emulsions are mechanical mixtures, depending on the vigorous pumping together of the ingredients to break the oil into droplets, and hence cannot be as perfect as the micellar emulsions prepared with soap. Kerosene can be emulsified more easily with cresoap or calcium caseinate than with boiling soap. Emulsion stocks should not be made to contain more than 75 per cent. of lubricating oil or 67 per cent. of kerosene or a reversed emulsion will result, which will not mix with water. If an oil spray breaks, showing a floating layer of oil or curds, the watery portion will probably be too weak to be effective, while the oily scum is injurious to trees. Soap emulsions are best where water is soft or alkaline, and non-soap emulsions where it is hard. Dormant sprays of lubricating oil should be applied when buds begin to swell in early spring. For scale-insects they should contain 4 per cent. of actual oil and for leaf-roller 8 per cent. A 2 per cent. oil spray, hitherto widely advocated, is too weak for San José scale [*Aspidiotus perniciosus*, Comst.] under Washington conditions. As a summer spray, 1 per cent.

of oil is useful for red spider and immature scales, but is not strong enough for old scales or for Aphids. Summer sprays containing more than 1 per cent. of oil may cause scorching if used in very hot weather on delicate plants.

A new formula for making Lubricating Oil Emulsions recommended in the U.S.A. is 1 lb. potash fish-oil soap (about 65 per cent. water), 4 (liquid) oz. amyl alcohol (fusel-oil), 1 U.S. gal. lubricating oil (spec. gr. 0·88 to 0·90) and ½ U.S. gal. water. It is important that the amyl alcohol be well stirred into the soap; the lubricating oil is then added slowly with vigorous stirring until the mixture appears as an oily salve. The water is then stirred in to form a creamy emulsion. This formula in dilute form retains its stability when mixed with Bordeaux mixture or nicotine sulphate. Cold stirred emulsions of this kind have given good results against various Coccids.

Lubricating-oil emulsion, made by the boiled process, for use against the San José scale is prepared as follows:

*Formula for stock emulsion.*

| | |
|---|---|
| Red engine oil | 1 gallon |
| Water | ½ ,, |
| Potash fish-oil soap | 1 pound |

The oil, water, and soap are placed in a tank and heated until the contents come to a boil. Just before boiling a brown scum appears on the surface of the mixture and as the boiling begins the brown scum will begin to disappear. At this stage the heat should be cut off and the entire mixture should be pumped twice under a pressure of about 60 pounds while still very hot. The first pumping may be made from the tank into a second container. The second pumping can then be made back into the original container or into barrels or other storage receptacles. Heating the mixture is not sufficient to produce an emulsion. The mixture should be boiled, but it is not necessary that the boiling continue more than a few minutes. In pumping, the entire contents should pass through a pressure pump twice. A rotary pump should not be used for the pumping. Stirring will not produce a proper emulsion nor should the mixture be allowed to cool before it is pumped.

The author's original recipes are as follow:—

1. *Petroleum mixed with Sand.*—Perfect division of the petroleum is obtained by mixing it with sand or earth as follows: Petroleum 1 litre, sand 4 litres (Ritzema Bos); petroleum 1 litre, sand 40 litres (Husson). It is used especially when a small amount of petroleum is to be spread over a large surface. The amounts given above suffice for 25 square metres of soil, say 30 square yards. The action of the petroleum in these conditions lasts ten to fifteen days.

2. *Petroleum Emulsion and Water.*—Petroleum is insoluble in water but it is capable of forming with it milky mixtures termed "emulsions," which have the properties of a solution. It is, however, difficult to obtain a perfect emulsion with these two bodies so different in density; even the special apparatus like that of Goff accomplishes the end in view with difficulty. Aqueous petroleum emulsions are very unstable, and petroleum aggregates quickly to reform a layer on the surface of the liquid. Petroleum and water emulsion is not perfect enough to allow

it to be used on the tender parts of plants, and it is now no longer used except to disinfect trees in winter, to spread petroleum uniformly over the field, and to disinfect seed. Lossen designed a simultaneous double jet of water and petroleum meeting with force in a common space, and producing a perfect emulsion, but this emulsion likewise dissociated on the surfaces touched, forming big drops of petroleum, always injurious.

3. *Lime and Petroleum Emulsion.*—Galloway recommends an emulsion made with 1 part of thick milk of lime from fat lime and 5—30 parts of petroleum. This emulsion is more stable than that made with water, but less so, however, than that made with soap solution. It was especially intended to be added to arsenical bouillies to increase their insecticidal value.

4. *Petroleum Emulsion with Salt Water.*—This emulsion is more difficult to make than that made with pure water, owing to the greater difference between the densities of the two products. It is frequently used in Switzerland, owing to its powerful properties against the woolly aphis: 8 lb. of petroleum are emulsified with 2 lb. of a 25 per cent. solution of common salt.

5. *Petroleum Emulsion and Soap Solution.*—Petroleum gives with soapy solutions very stable emulsions. All soaps do not lend themselves thereto equally well, whale oil soaps being the best. These emulsions keep a very long time whilst those made with other soaps become curdy in a few days. To increase the stability of emulsions made from ordinary soaps, alcohol or carbonate of soda is added. Concentrated stable emulsions are prepared with the appearance of a cream which are suitably diluted at the moment of use. A good preparation should be capable of being diluted to a certain extent without drops of petroleum forming on the surface of the liquid.

*Example.*—2½ lb. of soap are cut into thin slices and dissolved in 1 gallon of boiling water. After drawing the fire there is added slowly with constant stirring 10 gallons of petroleum at 18—20° C.; petroleum only emulsifies with difficulty below this temperature. To obtain a perfect emulsion it is necessary on the large scale to stir with a mechanical agitator, on the small scale with an ordinary spraying machine drawing in the mixture and expelling it repeatedly. The emulsion is more perfect if another gallon of boiling water be added and the whole mixed once more. Rain water or distilled water should be used, or hard water corrected by carbonate of soda. Very different mixtures have been recommended; the following are the principal ones:—

TABLE LIX.—*Showing the Ingredients of Several Petroleum Emulsions.*

| Water. | Petroleum. | Soap. |
|---|---|---|
| 10 gallons | 25 gallons | 50 gallons soft soap (Cooke) |
| 10 ,, | 10 ,, | 100 lb. soft soap (Kruger) |
| — | 10 ,, | 25 ,, ,, ,, |
| 10 ,, | 20 ,, | 6 ,, ordinary soap (Hubbard Riley) |
| 10 ,, | 6·7 ,, | 6·7 ,, ,, ,, (Ritzema Bos) |
| 10 ,, | 20 ,, | 12 ,, ,, ,, (Alvood) |

These emulsions are comparatively stable, less so, however, than those *made with whale oil* and intended to be kept. They are thinned when about to be used in such a way that the emulsion only contains 2·5—6 per cent. of petroleum, quantities which, according to Fleischer and Kruger, should never be exceeded if the emulsions are to be used on the tender parts of plants. Schoyen asserts that they do not damage the leaves, especially when the composition is unimpeachable. Generally dilute and homogeneous emulsions are made when about to be used; the following are some proportions recommended :—

TABLE LX.—*Ingredients of Four Stable Petroleum Emulsions.*

| Water. | Alcohol. | Petroleum. | Soft soap. | Carbonate of soda. | |
|---|---|---|---|---|---|
| 100 | — | 1 | 1 | — | Rathay |
| 100 | 0·5 | 2 | 3 | — | Caruso |
| 100 | — | 1 | 2 | 1 | Delacroix |
| 96 | — | 1 | 2 | 2 | Fleischer |

These four emulsions are very stable and can be kept. They are the best. Petroleum and soap emulsions have entirely replaced those of milk and petroleum. They are in current use in America.

6. *Emulsion of Petroleum with Fish Oil.*—There are emulsified together at 60° C. petroleum 15 lb., fish oil 2¼ lb., water 15 gallons.

7. *Petroleum and Milk Emulsion.*—Curdled milk forms perfect emulsions with petroleum : 2½ gallons of turned milk are diluted with 10 gallons of hot water, then 20 gallons of petroleum are added with constant stirring. Ten gallons of petroleum and 5 gallons of curdled milk can also be emulsified together. If it be desired to use fresh milk a little vinegar must be added. Sorauer prepares the fresh milk emulsion although it is not made so easily. To obtain a perfect emulsion the liquid to emulsify must be drawn in and expelled for three-quarters of an hour, if the mixture be at 16° C., during fifteen minutes at 24° C. This emulsion is diluted with twenty times its volume of water before use. The stability of this concentrated emulsion is less than that of a petroleum and soap emulsion. Unless it be kept in vessels absolutely closed it spoils in eight to fifteen days. According to Cooke, plants suffer more from this preparation than from petroleum soap emulsions.

8. *Petroleum Emulsion containing Insecticides and Metallic Salts.*—By adding to petrolo-saponaceous emulsions either extract of hellebore, arsenite of copper, or any other poisonous substance, the effect of the emulsion is strengthened and a more desirable action obtained. An emulsion, for example, is made with petroleum ¼ gallon, soft soap 7½ lb., hellebore 2½ lb., water 100 gallons. Smith advises the addition of 2½ per cent. of petroleum to a cupro-arsenical bouillie. The bouillie is stable, and the petroleum remains longer in fine division on the leaves than in pulverizing ordinary emulsions. According to the sensitiveness of the plant or the resistance of the insect submitted to the action of this bouillie, the dose of petroleum is increased or diminished. Kruger advises an emulsion made with equal parts of petroleum, soft soap,

and water, to which quassia or tobacco juice is added. Diluted before use with ten to twenty times its volume of water, this emulsion kills insects and prevents their return much longer than a simple emulsion. In South America flowers of sulphur are incorporated in the emulsions. They have been successfully used against *erinoses*. Galloway and Marlatt recommend adding a proper quantity, 2—6 per cent., of petroleum to Bordeaux bouillie. These mixtures are more stable than simple emulsions, they keep for eight days. Of all the emulsions described, those made with soap and petroleum are to be preferred.

For dormant and delayed dormant sprays in Pennsylvania, 3 U.S. gallons of red engine oil, 1½ lb. of calcium caseinate and a little water were mixed to make a stock solution, which was diluted with 300 U.S. gallons of water when required for use.

**Use against Injurious Fungi.**—*Potato Scab.*—This disease, characterized by an enormous development of the periderm, is caused by a special bacteria. It may be prevented if some hours before planting the soil be impregnated with an emulsion of soap 12½ lb., petroleum 4—5 gallons. This amount suffices for 24 square yards.

**Use against Coleoptera and their Larvæ.**—It is impossible to enumerate all the insects overcome by petroleum. The following are some typical examples :—

*Melolonthinæ* (cockchafers).—The larvæ of the cockchafers—*Melolontha vulgaris*, the common cockchafer; *Melolontha hippocastani*, the horse-chestnut cockchafer; *Melolontha fullo*, teasel cockchafer; *Lachnosterna arcuata*, red cockchafer—are destroyed, or at least so inconvenienced, by the presence of petroleum in the soil that they soon desert it. This effect is best obtained by burying to a depth of 30 inches rags steeped in petroleum. Perkins, and others obtained satisfactory results by the use of aqueous or soapy emulsions. They found that it was not enough to kill the larvæ of these insects to sprinkle the soil around the plants with 3·5 per cent. emulsions, for the larvæ descend into the untouched deep layers, from which they ascend some time afterwards. The results are, on the contrary, appreciable when the moment is chosen when the larvæ have regained the surface layers of the soil to dig deep narrow holes between the rows of the young pine or spruce plantations or round the vine stocks in vineyards. A 20 per cent. emulsion of petroleum is run into the holes, which are then filled up with earth, and an hour afterwards sprinkled with water. Used in this way, petroleum destroys a great portion of the larvæ of these lamellicorns, and protects the plant for a certain time against fresh attacks. In Norway, young plantations of conifers are successfully protected by pouring into the holes prepared before planting an emulsion of 1 part of petroleum with 13—15 parts of water. In America, Perkins advises spraying meadows with emulsions, harmless to grasses, to free them from the larvæ of the *Lachnosterna* and the *Allorhina nitida*.

*Elateridæ* (wire-worms).—The larvæ resist the usual insecticides better than soft-skinned larvæ. Comstock and Slingerland found petroleum emulsions without action on these larvæ. Perkins regards them as inefficient and Tarzioni-Tozzetti was only partially successful with an emulsion of petroleum with fish oil.

*Curculonidæ* (weevils).—To get quit of the anthonomes of flowers, and prevent them laying their eggs, very dilute emulsions of petroleum may be used, sprayed on the flowers before flowering. Schilling observed that this practice succeeded in freeing strawberries from the strawberry anthonome (*Anthonomus rubi*, Hbst.).

*Scolytidæ* (scolytides).—Winter treatment of trees by the petroleum emulsions destroys both *Xylophagus* insects which live in burrows dug in the bark of the trees, or immediately underneath it. F. H. Chittenden recommends this treatment especially against *Scolytus rugulosus*, Ratz. (scolytus of fruit-trees).

*Chrysomelinæ* (chrysomelines).–These may be destroyed by petroleum emulsions, especially if hellebore or quassia extracts be incorporated therewith. Comstock and others recommend the use of soapy emulsions as effective against *Criocerus asparagi* and *Phædon armoraciæ*, L. (chrysomelide of the radish), (cochlearia). They destroy the larvæ.

*Halticinæ* (altises).—Petroleum is very useful in destroying them, and its good effects on a large number of species have been recorded, viz.: *Haltica oleracea*, L.; *Phyllotreta nigripes*, F.; *Phyllotreta sinuata*, Steph.; *Phyllotreta undulata*, Kutsch.; *Phyllotreta nemorium*, L., injurious to the *Cruciferæ*; *Psylliodes affinis*, Payk., injurious to the potato; *Haltica vittula*, Redt., injurious to cereals; *Haltica rufipes*, L., injurious to peas and haricots. In the same way as the individual altises whose sensitiveness to petroleum has been the object of the above special observations, all altises in general are killed by petroleum. Care must be taken not to use too concentrated emulsions so as to safeguard the plant invaded by the ravisher and only use perfectly homogeneous preparations. This point is much more important, as the organs sought after by the altises are the most tender part of the plant, and, consequently, the most sensitive to the action of petroleum. Ritzema Bos advises to get rid of altises the use of an intimate mixture of 4 litres of petroleum and 16 litres of sand for 100 square metres of soil. Used on the spot invaded by the earth-lice, it is found that they immediately quit the plots treated and do not return until ten to fifteen days later. This method gets quit of altises when the plant is small and much exposed to complete destruction by the altise. Slingerland and others advise the use of emulsions with quassia extract for the same purpose. Petroleum and soap emulsions are perfectly capable of being of service to agriculturists as destructors of Coleoptera, especially when it is a question of their larvæ. In any case, the smell of petroleum is so objectionable that those not touched by it desert the plant treated. Lintner and others have shown that the eggs of the insects have such a resistance that a 30 per cent. emulsion of petroleum does not kill them.

**Use against Hymenoptera.**—*Lophyrus pini*, *Lophyrus rufus* (the pine saw-fly).—Ritzema Bos advises petroleum emulsions to destroy the larvæ of these lophyres. Their larvæ are very sensitive, especially when young. The treatment does not injure the pines.

*Ptereneus ribesii* (nematode of the gooseberry), (gooseberry saw-fly).—According to Johnson the young larvæ are killed by a 12 per cent. emulsion, the adults by the same emulsion containing 0·6 per cent. of hellebore decoction.

**Use against Lepidoptera.**—Lepidopterous caterpillars are generally very sensitive to petroleum, and easily destroyed. According to Bretscher the caterpillars do not resist a 3—6 per cent. petroleum emulsion. According to Schoyen a cupro-arsenical bouillie of 0·05 per cent. of emerald green is superior in its action to milk of lime emulsions. According to Moor the grubs touched appear for some time to be dead, but recover after a while.

*Pierides.*—White cabbage butterfly grubs are not killed except by a 6 per cent. emulsion of petroleum. At that concentration 75 per cent. of the caterpillars are killed. More concentrated emulsions are injurious to the leaves (Alvood). It is perferable to preserve cabbages by keeping off the butterflies. For that purpose it suffices, according to Prins's experiments, to sprinkle cabbages with a weak emulsion.

*Ocneria dispar*, Sch. (gipsy moth).—Petroleum emulsion is of great service. Berlese found that a 5 per cent. emulsion kills them outright. To destroy the eggs, pure petroleum must be used.

*Noctuidæ* (*Noctua*).—Petroleum emulsions kill the numerous caterpillars of *Noctuæ*.

*Agrotis Segetum*, W. V. (the common dart-moth grey-worm).—Not only are the caterpillars of the common dart-moth called grey-worms but also those of many other species of noctua, because they all have the same nocturnal habits and much resemble each other. These caterpillars often hibernate, and make considerable ravages in the spring by nibbling the young shoots of cultivated plants. The ravages are often so great that their destruction by petroleum is always necessary unless there be many toads on the spot, which are always great destroyers of these caterpillars. According to Decaux' experiments made in 1892, three toads suffice per acre to defend a crop. Riley advises to kill grey-worms on the large scale by an emulsion containing 0·5 per cent. of soap and 1 per cent. of petroleum, which is sprayed on the fields at the rate of about 1000 litres per hectare (88 gallons per acre). Degrully advises a mixture of sulphur 6 lb., lime 4 lb., petroleum 10 gallons. Burning rags steeped in petroleum drives them away without destroying them.

*Charaeas graminis.*—The caterpillar of this butterfly devastates meadows when it appears in great numbers (Bremen, 1816 and 1817). Reuter found that they resist a 6·6 per cent. emulsion.

*Mamestris brassicæ*, L. (the cabbage moth).—The invaded cabbages must be sprinkled with a 6 per cent. petroleum emulsion. A weaker emulsion may be used as a preventive before the butterflies lay their eggs on the young cabbage. Petroleum emulsions have likewise been tried to combat Tortricides.

*Cochylis ambignella*, Hubn. (cochylis of the vine).—Zecchini and Silva found that its caterpillar, the worm of the vintage, is destroyed by an emulsion of 2·5 per cent. of petroleum and 1 per cent. of soap. The vine leaves are sensitive to greater strengths; this dose should not be exceeded.

Amongst the Tineides or Tinea [1] :—

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[1] TINEA.—Small moths, distinguished by long antennæ, narrow and pointed at their extremities, and by large fringes which line the periphery of their wings, especially the lower wings.

*Plutella cruciferarum*, Zell. (diamond-back moth).—Petroleum is used in the same way as to combat the cabbage noctua. They are easier killed if the emulsion contains quassia extract (Fleischer).

*Hyponomeuta malinella*, Zell. (small ermine apple moth).—Schoyen advises a 10 per cent. emulsion against the caterpillars of this tinea. The results are grand. At that strength the emulsion even kills the chrysalides. The action of petroleum can be localized on the nests by applying with a brush a 12 per cent. emulsion in the evening when all the caterpillars have re-entered the nest.

**Use against Hemiptera.**—The phytophagus bugs are destroyed by petroleum emulsions.

*Eurydema ornatum* (*Pentatoma ornata*[1]), *Eurydema oleraceum* (*Pentatoma oleraceæ*[2]).—To kill this bug it takes strong (6—10 per cent.) emulsions of petroleum; generally they injure the plants as much as the bugs. To obtain a perfect result Wood advises to operate thus: Intercalate in the crops affected by these insects the plants preferred by them, on which they are not long in installing themselves in mass. On these they are destroyed with strong emulsions, which kills them at the same time as the bait plants. In this way, between rows of potatoes, mustard, radishes or other crucifers are planted.

*Lygus pratensis*[3] (meadow bug).—Many be destroyed by a 15 per cent. petroleum emulsion.

*Haltica Uheleri*[4] (Giard).—Petroleum emulsions destroy it (Chittenden).

*Oxycarenus hyalinipennis*, Costa (cotton bug).—Marshal destroys it with petroleum emulsions.

*Tingis piri* (tiger beetle of the pear).—These are killed by spraying under the leaves principally an emulsion containing 1 per cent. of soft soap, 1 per cent. of petroleum, and 1 per cent. of carbonate of soda. According to Debray, the winter treatment of fruit trees with 12—25 per cent. emulsions destroys these injurious insects in their winter refuges.

**Use against Homoptera.**—The *Cicadellides*, small grasshoppers, a few millimetres in length, are often injurious to crops. Petroleum emulsion kills them effectually.

*Jassus sexnotatus*, Fall. (grain grasshopper).—Sorauer has used with success a milk emulsion of petroleum consisting of 2 parts of petroleum and 1 part of milk, diluted with twenty times its weight of water. Used against the grain grasshopper it is more active than lysol and Nessler's liquor.

*Typhocyba Solani*, Kll. (potato grasshopper).—Von Schilling recommends the use of soapy emulsions of petroleum to destroy this grasshopper. It is, however, well to use a strong emulsion, and wash the plant afterwards by spraying with water, as soon as the petroleum has acted on the grasshoppers.

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[1] PENTATOMA ORNATA (the decorated bug).—Piebald bug, red and black, 1 centimetre long. The female lays its eggs on the lower surface of the leaves, they are placed so as to form bands. The larvæ, like the adults, suck the juice of the leaves.

[2] PENTATOMA OLERACEÆ (cabbage bug).—Green bug with red marks on the female, white marks on the male, 6 millimetres long.

[3] LYGUS PRATENSIS (meadow bug).—This bug is sometimes very injurious to apple-tree and pear-tree buds.

[4] HALTICA UHELERI.—This altise sucks the leaves of the potato.

*Penthima atra* (grasshopper of the vine).—Marlatt found that a 6 per cent. emulsion kills this grasshopper. The vine only supporting a 2·5 per cent. emulsion, the treatment should be followed immediately by washing the stocks treated with a spray of pure water. The psyllas or leaf lice are closely related to the aphis; they also are injurious to trees. They are killed by petroleum emulsions.

*Psylla piri*,[1] L. (the pear chermes).—The larvæ are very sensitive to petroleum emulsions and may be destroyed, whilst the adults are more resistant. According to Marlatt and Slingerland, 33 per cent. emulsions do not act on the eggs, besides they resist pure petroleum, benzene, spirits of turpentine, carbolic acid, and liquid soda. Winter treatment with 25 per cent. emulsions destroys the hibernating adults. Spring treatment with 2 per cent. emulsion, at the time of the hatching of the larvæ, destroys 90 per cent. Fischer recommends the extract of quassia emulsion.

*Psylla mali*, Förster (the apple hermes).—Winter treatment is without effect, for it is not the adults that hibernate but the eggs. It is better, therefore, to treat the larvæ in the springtime, some days after hatching, to obtain appreciable success.

*Aphides* (lice), are easily destroyed by emulsions when they are not sheltered in a fold of the leaf in galls (*Tetraneura*) or in cankers (*Schizoneura*) inaccessible to sprays. It is well, therefore, to proceed with the treatment before the louse has assumed a great extension, at the moment when it is discovered. In these conditions the destruction succeeds, even with the Delacroix 1 per cent. emulsion. Nevertheless, Koebele and others recommend a 3 –4 per cent. emulsion against the living lice in the open, as those of the rose. When the lice are protected under a curled leaf, as in the case of the apple, peach, and gooseberry, the treatment does not succeed; 6·6 per cent. emulsion only killed 25 per cent. of the gooseberry aphis. Kruger's emulsion, consisting of equal parts of soft soap, petroleum and water, is most used in Germany and diluted so as to make a 1—6 per cent. emulsion; in France it is Delacroix's containing 2 per cent. of soft soap, 1 per cent. of petroleum, and 1 per cent. of carbonate of soda. The winter treatment of trees with concentrated emulsions, containing 25 –30 per cent. of petroleum, cannot act except on species which hibernate in the state of apterous females, for these emulsions are, according to Goff, incapable of killing the winter eggs.

*Aphis pomi.*—The stock emulsion double distilled coconut fatty acid, 200 c.c., gasoline (benzol) 200 c.c., glue (granular) 100 gm., and water 525 cc., used at the rate of 1 part to 800 –1,200 parts of water, produced a mortality of 94—98 per cent.

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[1] Psylla.—Hemiptera, distinguished from the plant lice by the arrangement of their legs which enables them to jump; besides they do not present asexual and sexual generations, alternating the one with the other; they are all sexual. Psylla of the Pear. *Pyslla piri.*—This *Psylla* as well as *Psylla piricola*, which are only to be distinguished from one another by their different colour, cause great ravages on pears. The *Psylla* appears towards the end of May after having passed the adult state in the anfractuosities of the bark. After coupling, the female lays its eggs on the leaves and young branches, which then appear as if dusted with yellow. The apterous larvæ which hatch in a few days pierce and suck the parenchyma of the leaves and the young branches; the latter especially bend and perish.

*Schizoneura lanigera*, H. (woolly aphis). -The woolly aphis forms big cankers on the branches on which the colonies vegetate indefinitely. These pests form hiding-places there, where it is almost impossible to reach them, and as they are, moreover, covered with a sort of down, aqueous insecticides have no action on them, for they neither reach nor penetrate them. The moment must be chosen when the winter egg is hatched, for at birth the insects have no down, are delicate and frail. Concentrated emulsions containing as much as 66 per cent. petroleum can then be used on the cankers, preferably after excising the ligneous portion. Success is absolute, yet Delacroix and Fischer remark that an ordinary 3·5 per cent. emulsion, and even with 1 per cent. of petroleum and 1 per cent. of carbonate of soda, acts on all the lice it touches. Failures only occur with too thick colonies that cannot be penetrated by the insecticide. In Switzerland, petroleum and salt water emulsions are used with success. According to Stedman (Missouri Experimental Station), the ravages of the woolly aphis also affect the underground portion of the apple-tree. He succeeded in disinfecting the young trees without injuring their health, by uplifting them, cleaning their roots, cutting out any nodosities if need be, and immersing the roots in a petroleum (kerosene) bath consisting of 2½ lb. of soft soap, 9 gallons of petroleum, and 90 gallons of rain water.

Against the green peach aphis of California and elsewhere, a remedy that has proved successful consists of 1 gallon miscible oil with sufficient washing soda to produce a thorough emulsion, in 25 gallons of water; this should be applied in late winter or early spring, but not later than when the buds are just beginning to swell.

For use against woolly aphis (and other pests) the British Ministry recommend a spray of: Paraffin 4 pints, soft soap 1½ lb., water, 10 gallons. The soft soap is dissolved in about a gallon of boiling water and the paraffin added while still hot, but away from fire. Before use add the other 9 gallons, mixing thoroughly, keeping stirred or emulsified with the syringe. Against ermine moths and mussel scale (*Mytilaspis pomorum*, Bouché) the quantity of paraffin is increased to one gallon.

*Pseudaonidia duplex* (Chll.).—After this camphor scale was discovered in New Orleans, shade trees were severely pruned and then sprayed with oil emulsion. The formulæ recommended are: 2 U.S. gallons light oil (Diamond paraffin), 1 U.S. gallon water, and either 4 oz. calcium caseinate or 2 lb. potash fish-oil soap. The emulsion with calcium caseinate will mix with lime-sulphur solution, whereas the other will not. For *Citrus* the emulsions should be diluted with 40 U.S. gallons water for winter spraying or 50 for summer spraying.

*Coccides.*—In spite of the thick shell which protects the coccides, they may be overcome by petroleum and its emulsions when they live in the open. Petroleum is one of the rare substances which really act on coccides. In the pure state its action is radical. It is recommended in that state when it is a case of a dangerous invasion which must be stopped by the complete destruction of the parasite. When coccides such as *Aspidiotus perniciosus*, Comst. (San José louse), *Aspidiotus* *ostreaformis*, Curtis (pear-tree oyster scale), an American coccid the appearance of which was first reported in France in 1892, *Mytilaspis pomorum*, Hook (apple-tree mussel scale), *Diaspis piricola* (pear coccis), and others—when these make their first appearance in an orchard, pure petroleum must be used, taking the precautions previously described—precautions which are indispensable to preserve the tree in good health and circumscribe the plague. In most cases emulsions may suffice, and where the dangerous coccides are in the endemic condition, as in America, regular annual treatment with dilute emulsions prevents their too great multiplication in orchards without completely destroying them. It is the same with the coccides as with the phylloxera. There is an extinction treatment when this insect makes its first appearance, and a cultural treatment where it lives in the endemic state and where it suffices to create a *modus vivendi* between the tree and its parasite. Cultural treatment is effected with dilute solutions, especially if the moment chosen for treatment be that when the young delicate larvæ emerge from the protective carapace of their mother, where they have been sheltered during the first days of their larval evolution. At that time they are as sensitive as the aphides and succumb to 2·5 per cent. emulsions. (Fleischer) or 6·6 per cent. (Kruger), which no longer injure the tree. The adult females covered by their carapace are more resistant. In winter, 25—30 per cent. emulsions must be used against *Aspidiotus*, 12—15 per cent. against *Lecanium nigrofasciatum* (kermes of the peach, Johnson), 5—10 per cent. against kermes of the lemon-tree. It is well to give several treatments, at eight or fifteen days' interval, as advised by Belle, and to follow this winter treatment by a spring treatment with a weak emulsion intended to destroy the active larvæ. In this way the treatment is complete and without injury to the fruit tree. Belle advises this treatment to destroy *Chrysomphalus minor* (orange coccis), Targioni-Tozzetti to destroy *Pulvinaria vitis*, L. (vine coccis), and Marchal to overcome *Guerinia serratulæ*, Fab. (kermes of the pine, cypress, and acacia). Petroleum and its emulsions applied judiciously are capable of easily destroying the coccides.

*Chrysomphalus dictyospermi.*—For protection of *Citrus* on the Mediterranean coast preparations of oil emulsion are recommended, the best of which is prepared as follows. A smooth paste is made of 5 lb. flour to about 2 gallons water, and this is added while hot to 10 lb. soft soap, beating the solution well with a stick or metal whisk. The solution is then emulsified with 50 to 100 lb. mineral oil (anthracene oil or common motor oil, density 0·910) according to the concentration required. The emulsion can be prepared several days before it is required for use, when it should be diluted to 100 gallons, emulsifying vigorously all the time.

**Use against Diptera.**—*Psila rosæ*,[1] Fabr. (carrot fly); *Anthomyia brassicæ*,[2] Bouché (turnip fly).—Schoyen recommends 12 per cent. emulsions to overcome these flies, which do great damage.

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[1] Psila rosæ (carrot-fly).—The larva of this small fly, of not more than 4—5 millimetres, is black with yellow head and legs. It dwells in the carrot and there bores holes which cause the root to rot.

[2] *Anthomyia brassicæ* (turnip-fly, cabbage-fly).—Length 7 millimetres, colour blackish-grey, eyes red. It flies in the month of May and lays its eggs in the collar of the *Cruciferæ*.

**Use against Acari.**—*Tetranychus telarius* (red spider).—Kolbe advises the use of an emulsion of 1 per cent. of petroleum and 1 per cent. of soap, Fernald that of an emulsion containing quassia. Emulsions of 3—4 per cent. containing a little suspended sulphur are also recommended.

For use against "red spider" (*Tetranychus telarius*) :—Paraffin jelly according to Theobald's formula is recommended by the British Ministry of Agriculture. Paraffin, 5 gallons, soft soap, 8 lb. Boil the soft soap and paraffin together and, when boiling, add 1 pint of water and stir well. This becomes a jelly on cooling; add 10 lb. of this jelly to every 40 gallons of water. Owing to possible danger from fire the boiling should take place out of doors and away from buildings.

*Paratetranychus pilosus,* Can. and Franz. (European red mite).—In Maryland, miscible oils or oil emulsions give the best results against the winter eggs; oil and soap emulsions, either proprietary or home-made, have given as good results at a dilution of 1 : 33 as most of the miscible oils at 1 : 15.

*Gossyparia spuria,* Mod.—A spray of 16 gallons of miscible oil (23—28° Bé.) with 184 gallons of water is recommended in the U.S.A., against European elm scale.

*Phytoptides.*—To destroy them action must be taken the moment they invade the buds, that is to say, at the moment the acari are grouped around these. This treatment is especially used in South America where acari cause frequent ravages.

**Petroleum Spirit.—Preparation.**—Petroleum spirit is rectified petroleum, collected by distilling the hydrocarbons boiling between 100° and 150° C. (212—302° F.).

**Action on Plants.**—Petroleum spirit is regarded as less injurious to the tender parts of plants than petroleum oil; applied by spraying on the plant it evaporates more rapidly and the plant does not remain so long in contact with it.

**Action on Insects.**—Petroleum spirit appears less active on insects than petroleum oil, and it must be used in larger doses than the latter. Used in the soil, its radius of action is more extended, which renders it more apt to overcome underground insects.

**Use.**—Alvood and Slingerland tried to replace petroleum oil emulsions by petroleum spirit, but they found the latter inferior. Mohr, on the other hand, reports the good services rendered against underground parasites by the following emulsion :—

Mix together 2½ lb. of oleic acid and 2½ lb. of ammonia, then add 1 gallon of petroleum an 1 gallon of petroleum spirit. By an intimate mixture made by a spraying machine a stable emulsion of syrupy consistence is obtained. For the destruction of underground parasites, such as nematodes, larvæ of melolonthides, noctua wire-worms, mole crickets, etc., 1 gallon of this emulsion is mixed with 20 gallons of water. The dilute emulsion contains about 4 per cent. of petroleum, and behaves in the same way as the ordinary emulsions of soap and petroleum. To obtain complete destruction Mohr says it is not enough to spread the preparation in the soil; holes must be pierced every 20 centimetres (8 inches), 30 centimetres (12 inches) in depth, and into which 20—30 cubic centimetres of emulsion, say up to a fluid ounce, are poured; then the holes are plugged.

*Ceutorhynchus sulcicollis*,[1] Gyl. (cabbage weevil).—Underground injections of diluted Mohr's emulsion kill it, also the following: *Otiorhynchus sulcatus*[2] (vine weevil); *Molytes coronatus*,[3] L., weevil injurious to beets, because it perforates their leaves.

*Cochylis ambignella* (cochylis of the vine).—Del Quercio advises an emulsion of 1 per cent. petroleum and 1 per cent. of soft soap. Caruso got excellent results by a bouillie of 2 per cent. petroleum spirit, 3 per cent. soft soap, and 0·5 per cent. alcohol. As for petroleum emulsions, this emulsion must be made ten times more concentrated, and diluted at the time of use by hot water. By applying this emulsion on the caterpillars, Martini destroyed 94 per cent., whilst Dufour's pyrethrum bouillie only destroyed 79 per cent., and rubinia (wood tar) of 5 per cent. strength only 73 per cent.

*Tingis piri*.—Del Quercio describes the good effects of an emulsion of petroleum 1 per cent. and soft soap 1 per cent

*Lopus sulcatus*[4] (*grisette de la vigne*).—Pratigeon destroys the adult larvæ by emulsions of petroleum spirit, or of carbon disulphide. So as not to hurt the vine, he begins the treatment at the time when this insect has already invaded the young grapes; but it must be attacked before hatching on the plants on which it feeds most willingly. A slight shake is given to the stock; the larvæ, which are already clinging to the vine, fall to the ground forthwith and the emulsion is then projected on to the soil. To kill the perfect insect, an emulsion diluted to at least 2 per cent. is projected on the fruit.

**Petroleum Jelly.—Action on Plants.**—Petroleum jelly is not harmless to plants as might be imagined. It acts injuriously like petroleum hydrocarbons. Shearer found that plants do not support with impunity larger doses than 10 per cent. Goethe and Marchal found that petroleum jelly used as an asphyxiating ointment on the cankers produced by the woolly aphis is injurious to the plant.

**Action on Insects.**—Like oils and fats in general, petroleum jelly acts on insects as an asphyxiant; it would appear at the same time to exercise a toxic action analogous to that of petroleum on insects and their larvæ; contact with it or its emulsions diluted even to 10 per cent. is deadly.

**Use.**—Petroleum jelly has been used to prepare the sulphuretted grease invented by Meunier, to overcome the phylloxera. Petroleum jelly rapidly diminishes the evaporation of carbon disulphide in the soil, and prolongs its action. It forms emulsions with soapy water of the same strength as petroleum, and such emulsions are used in the same condition; they are especially used in England. Ward advises an emulsion of jelly 0·5 per cent., soap 1·25 per cent., against all garden insects.

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[1] CEUTORHYNCHUS SULCICOLLIS (cabbage and turnip gall weevil).—Black, 3 millimetres long, appears in May, attacks all crucifers, cabbage, rape, colza, turnips, mustard, etc. The female lays its eggs in July in the roots or the lower part of the stem. The larvæ attack the bark.

[2] CURCULIO (OTIORHYNCHUS) SULCATUS (grooved weevil otiorhynchus, vine black).—This small weevil attacks the vine, the strawberry plant, and various ornamental plants.

[3] MOLYTES CORONATUS (carrot weevil).—Brilliant black with some yellowish spots, 12 millimetres long. In May the eggs are laid in the soil, the larvæ penetrate into the lower parts of the carrot and ascend it by excavating burrows.

[4] LOPUS SULCATUS.—This bug of 7 millimetres with yellow bands and points, appears at end of May and attacks the flower buds of the vine, sinking its sucker into them.

*Anthomyia betæ* (beet fly); *Anthomyia antiqua*,[1] Meig. (onion fly); *Anthomyia furcata*, Bché. (onion fly); *Anthomyia ceparum* (onion fly); *Psila Rosæ*, Fabre (carrot fly).—Whitehead destroys these flies by an emulsion of petroleum jelly 10 per cent., soft soap 0·25 per cent. It is used as a spray round the plant before the appearance of the fly.

*Thrips cerealium* [2] (thrips of cereals).—Shearer destroys these insects by spraying with emulsions of petroleum jelly 7 per cent., soft soap 8 per cent.

*Aphides.*—Plant lice are killed by an emulsion of petroleum jelly 0·75—1·0 per cent. and soft soap 0·5—0·75 per cent. (Whitehead); petroleum jelly 3·5 per cent. and soft soap 7 per cent. (Shearer).

*Coccides.*—To kill coccides and kermes emulsions of petroleum jelly 10—12 per cent., soft soap 8—10 per cent., must be used.

**Acetylene,**[3] $C_2H_2$.—**Preparation.**—Coal gas destroyed by sparking or incompletely burnt yields this unsaturated hydrocarbon. It is obtained commercially by decomposing with water acetylenic carbides, such as calcium carbide.

$$CaC_2 + 2H_2O = Ca(OH)_2 + C_2H_2.$$

As the commercial carbide is always impure, there is formed in addition ammonia 0·24—0·4 per cent., sulphuretted hydrogen 0·7—0·9 per cent., phosphuretted hydrogen 0·018—0·032 per cent. (Chuard).[4]

**Properties.**—Acetylene is a colourless gas with a slight alliaceous odour; it burns with a bright flame. One kilogramme of calcium carbide disengages 300 litres of acetylene.

**Action on Plants.**—Acetylene has no injurious action on plants. Leoni found that the germinative capacity of peas and grain did not suffer from its contact. At a certain strength it must, however, act like coal gas, which is known to be injurious to plants.

**Action on Fungi.**—Calcium carbide applied with the bellows, like sulphur, and projected on to the fungi moistened with water, appears to be injurious to them, but it only kills the fungi touched. Moreover, the action of acetylene on fungi is still badly understood.

**Acetylene tetrachloride,** $CHCl_2{\cdot}CHCl_2$.—Action of chlorine on acetylene. Fumigation with a preparation containing tetrachlorethane has been found to kill aphides (*Macrosiphum persicæ*) infesting seed potatoes, exposure for 1 hour at 50—60 deg. F. sufficing.

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[1] ONION-FLY. Three species: *Anthomyia antiqua, A. furcata, A. ceparum.*—Small flies of 7—8 millimetres, which lay their eggs end of April and May on the leaves of the onion.

[2] THRIPS OF CEREALS. *Thrips cerealium.*—This hemiptera of 2 millimetres is a dangerous parasite. The larvæ attack the ears of wheat, rye, and barley, where they suck the newly formed grains, and stop their development.

[3] Acetylene is like coal-gas, explosive when mixed with a certain amount of air. Anyone storing calcium carbide must comply with the Home Office regulations thereanent.—TR.

[4] Chuard and Ettli believing that phosphuretted hydrogen may aid to a great extent the insecticide action of calcium carbide, prepared calcium phosphide, $Ca_3P_2$, which is decomposed by water into lime and phosphuretted hydrogen, so as to test it comparatively against calcium carbide.

**Action on Insects.**—Placed in an atmosphere containing 10 per cent. of acetylene insects die in twenty-four hours. Perfect insects and larvæ of the pea weevil, *Bruchus* (*Bruchus pisi*, L.), hidden in the peas die by the acetylene disengaged when they are enclosed with a small piece of calcium carbide in a closed space.

**Use.**—*Oidium Tuckeri*, Berk. (oidium of the vine).—Huchet was the first to try calcium carbide on the vine to kill oidium. After moistening the diseased grapes with the spraying machine, finely pulverized calcium carbide was applied by a sulphur bellows. The effect produced was decisive, and in spite of the great heat, neither the grapes nor the leaves suffered. Since then calcium carbide was tried, comparatively, against sulphur in Champagne in the vineyards of Chandon de Briailles, with the result that sulphur and calcium carbide cannot be used indifferently in the different phases of the disease. When a stock attacked by oidium has been treated with sulphur, it may be taken for granted, if rain does not intervene and if the weather is warm, that the vine has been protected against the disease for a month at least. But the very great efficiency of sulphur when the disease is recent is less when the attack is an old one. Calcium carbide does not kill the oidium except when it is in contact with the fungus, and, moreover, so that it can act the attacked grapes are moistened when the carbide dust is projected on to them. Under such conditions, the action of the product is somewhat energetic on strongly attacked grapes. In similar circumstances the action of sulphur would be less pronounced. The use of calcium carbide would not appear to be indicated except on grapes to overcome an old and intense attack of oidium, when the sulphurings have not been numerous enough or when weather conditions have diminished the destructive capacity of sulphur.

*Guignardia Bidwelli*, V. and R. (black rot of grapes).—In the beginning of September, G. Rodies dusted with calcium carbide the tendrils of the still green grapes attacked with black rot. Some days after this treatment the fungus had disappeared. Held describes the injurious action of the lime from acetylene factories used in place of ordinary lime to coat trunks of fruit trees.

**Destruction of Insects.**—*Melolonthides* (cockchafers).—Scribaux and Chuard recommend acetylene against the enemies of crops. They propose to incorporate in the soil, preferably deep down, a sufficient quantity of calcium carbide in small pieces, which by the moisture of the soil would be decomposed into acetylene. This decomposition occurs slowly and gradually. An insecticide gas is formed capable of occupying a considerable volume of the soil treated. Weak doses in Germany had no effect. Pieces of carbide of about 50 grammes, say $1\frac{3}{4}$ oz., buried 8 inches down every metre is not enough, as 1 kilogram only yields 300 litres of gas (1 lb. yields 30 gallons).

*Phylloxera vastatrix* (phylloxera of the vine).—Chuard tried the cultural treatment of the vine against phylloxera by means of calcium carbide. His trials in the neighbourhood of Annecy show that vines treated with carbide exhibit a greater vitality and vigour than the neighbouring untreated stocks, and on examining several stripped stocks the phylloxera was absent. The process consisted in stripping the roots and adding 100 grammes, say 3½ oz., of coarsely crushed carbide. Trials in Germany, on the contrary, proved that carbide is unable to overcome the phylloxera. The question is far from decided, and it is very possible that in carbide we possess an excellent insecticide capable of freeing crops from underground parasites.

# CHAPTER XIX

CARBON COMPOUNDS (*continued*)—CHLOROFORM—CARBONIC OXIDE—METHYL ALCOHOL—ETHYL ALCOHOL—AMYLIC ALCOHOL—GLYCERINE (TRI-HYDRIC ALCOHOL)—ETHER—MERCAPTAN—FORMIC ALDEHYDE—ACETIC ACID—OXALIC ACID.

**Chloroform,** $CHCl_3$.—**Preparation.**—Heat in a retort bleaching powder 10 lb., slaked lime 3 lb., ordinary alcohol 2 lb., water 6 gallons. The reaction commences at 80° C., and when the heat is lowered continues. Chloroform distils. The operation is stopped when 0·3 gallons of liquid has been collected. The liquid separates into two layers, the heaviest of which is chloroform.

**Properties.**—Chloroform is a colourless, very fluid liquid, with a sweet, pleasant odour, and a sharp, saccharine taste. It is only slightly soluble in water, but very soluble in alcohols. Chloroform is a powerful caustic; applied on the skin it irritates it to vesication and produces local anæsthesia; its anæsthetic action is due to a muscular paralysis of the heart. An atmosphere containing 4 per cent. of chloroform is irrespirable. It is deadly at 8 per cent.

**Action on Plants.**—Its action resembles that of ether. Coupin submitted seeds to the action of chloroform vapours, and found that the dry seeds did not suffer in an atmosphere saturated with chloroform. It is quite otherwise with moist seeds, the protoplasm of which already shows some action. They are very sensitive to chloroform, and an atmosphere containing 0·037 per cent. (3·7 grammes) in 10 litres of air is deadly. Wheeler made different trials to disinfect seed-corn by the vapours of ammonia, formol, and chloroform. He found grain stood the action of ammonia for twenty minutes, formol sixty minutes, and chloroform ten minutes, without losing their germinative capacity. Chloroform has a very peculiar action on the growth of plants. Mrs. Latham found that chloroform stimulated the growth up to a certain concentration and then slackened it. Kegel found on *Elodea* that the stimulating action of chloroform is only shown between 0·4 and 0·7 per cent., but that above or below these strengths growth is retarded.

[**Forcing by Chloroform.**—Professor Johannsen, of Copenhagen, has been chloroforming plants, and with marvellous results. He discovered that plants treated with anæsthetics were stimulated into extraordinary growth. His method is this:—

Lilies of the valley, azaleas, lilacs, and other dormant plants are placed in an air-tight box, to the lid of which is affixed a small vessel filled with chloroform. This, being heavier than air, settles down and mingles with the plants. At the end of forty-eight hours the specimens are taken out and grown in the ordinary manner.

Nothing in the way of forcing or artificial heat is required. Lilacs bloom within two weeks of being chloroformed, and lilies of the valley are hardly so long in coming to maturity.—Added by TRANSLATOR.]

**Action of Chloroform Vapour on Spores.**—Wheeler compared the action of formol, chloroform, ammonia, and carbon disulphide on the spores of *Tilletia* with the view of discovering a practical process for the disinfection of seed-corn by anticryptogamic vapours. He found that only the vapours of formol entirely accomplished the end in view. Seed-corn is placed in a tube and the vapours of anticryptogamic substances are passed through it by aid of an air current. Wheeler in that way obtained the following results :—

TABLE LXI.—*Showing the Disinfectant Capacity of Anticryptogamic Vapours on Seed-corn.*

| Kind of vapour. | Action. | Diseased ears, per cent. |
|---|---|---|
| Formol vapour . . . . | 15 minutes | 0·00 |
| Untreated . . . . . | — | 1·35 |
| Ammonia vapour . . . . | 60 minutes | 0·19 |
| Untreated . . . . . | — | 0·48 |
| Carbon disulphide vapour . . | 21 minutes | 0·15 |
| Untreated . . . . . | — | 0·35 |
| Chloroform vapour . . . | 10 minutes | 0·25 |
| Untreated . . . . . | — | 0·35 |

**Action on Insects.**—Chloroform is poisonous to insects, its vapour kills them.

**Use.**—Coupin advises that in the struggle against the insects infesting granaries, carbon disulphide be replaced by chloroform which has the advantage when used on dry grain of not damaging it like carbon disulphide.

*Coccides.*—Reh found chloroform vapour acts very energetically against coccides. Coquillet who tried it against the coccus of the orange-tree and lemon-tree did not record perfect results.

**Carbonic Oxide,** CO.—**Preparation.**—This gas is formed on every occasion that there is incomplete combustion of carbon owing to an insufficiency of air to form carbonic acid [to which it burns in air].

**Properties.**—Carbonic oxide is a poisonous gas. In doses of 4—5 per cent. in the air it causes the immediate death of animals. This action is explained by the way it behaves to the hæmoglobin of the blood. By the combination which it forms with the latter it annuls more or less completely the property of the globules to fix oxygen.

**Use.**—Carbonic acid is used to kill the chrysalis of the silk-worm by submitting the cocoons for eight hours to the action of this gas. Coquillet also tried unsuccessfully to destroy coccides by the use of this gas.

**Alcohols.**—The alcohols enter into the composition of many insecticides because they are capable of mixing in all proportions with water, and maintain in solution therein the insecticides insoluble in water.

**Methyl Alcohol,** $CH_3OH$.—**Preparation.**—Methyl alcohol or wood spirit is a product of the dry distillation of wood.

**Properties.**—Methyl alcohol is a colourless mobile liquid which boils at 66·5° C. It dissolves most substances soluble in ordinary alcohol, such as essential oils and resins. Oxidizing agents convert it first into formol and then into formic acid. [Highly inflammable.]

**Use.**—As a solvent in place of ordinary alcohol which it can replace in all insecticides with an ethylic alcohol basis.

*Phylloxera.*—Two mixtures have been patented in Germany for the destruction of this pest. The D.R.-P. 50772 claims a solution of turps and quassia in methyl alcohol, and D.R.-P. 47775 claims a solution of animal oil, colocynth, etc., in methyl alcohol.

*Galeruca luteola* (galeruca of the elm); *Erymia nitida* (diptera living on the elm).—It is recommended to destroy these by a mixture of water 100 gallons, tobacco juice 1 gallon, soft soap 10 lb., methyl alcohol 1 gallon, carbonate of soda 2 lb.

**Ethyl Alcohol,** $C_2H_5OH$.—**Preparation.**—By the action of yeast on saccharine solutions certain sugars are under such conditions converted into alcohol and carbonic acid. All that has to be done is to distil these liquids to obtain alcohol. Purification is effected by redistillation of the first distillate over lime.

**Properties.**—Alcohol is a colourless limpid liquid with an intoxicating odour; it dissolves in water in all proportions. Alcohol is a good solvent not only of inorganic compounds like caustic alkalies, mineral acids, chlorides, and nitrates, but also of numerous organic compounds, such as essential oils, resins, camphors; it also dissolves fatty bodies, but with greater difficulty. Alcohol boils at 78·4° C.

**Action of Alcohol on Plants.**—Sandsten examined the action of alcohol on the growth of plants in a nutritive fluid. Alcohol in solution of 1 in 10,000 to 1 in 20,000 does not affect the growth of young plants of phaseolus, vicia, and maize. A 2 per cent. solution is injurious, it excites the movements of the protoplasm and causes death. The vapours of alcohol may become prejudicial to the health of the plants if the atmosphere contains more than 1 in 10,000; greater amounts stop growth and cause death. Hiltner found that whilst ordinary alcohol of 95 per cent. strength injures seed, absolute alcohol on dry seeds has no injurious effect. Alcohol would appear, therefore, to act on seeds like ether and chloroform.

**Use against Insects.**—**Disinfection of Flower Seed.**—Hiltner recommends to wash with absolute alcohol. The seeds should be dry and thus without protoplasmic activity.

**Plant Lice.**—Alcohol enters into the composition of many insecticides recommended against plant lice, but it is not so active as amylic alcohol which replaces it with advantage in all these mixtures.

*Schizoneura lanigera,* Hausm. (woolly aphis).—Linière recommends a mixture of alcohol 30 oz., water 20 oz., potash 1 oz., applied by the brush on the colonies. In Germany this aphis is easily got rid of by drenching the colonies and the cankers which they produce, and which protect them, with methylated spirit, which is then lighted. Reh found that alcohol does not kill coccides after two hours' action.

**Amylic Alcohol,** $C_5H_{11}OH$.—**Preparation.**—Crude ordinary alcohol always contains a certain proportion of amylic alcohol, especially if from the fermentation of potatoes. Amylic alcohol results from the secondary fermentation due to special ferments.

**Properties.**—Crude amylic alcohol used in agriculture is a colourless fluid with a sweetish smell which boils between 129° C. and 132° C. It is not perceptibly soluble in water, but it dissolves in ordinary alcohol.[1]

**Action on Plants.**—It is more poisonous to plants than ordinary alcohol. Mixtures of soft soap and amylic alcohol cannot always be used with impunity on plants without killing them. But this is greatly due to the action of the soft soap on the leaves and the young shoots of which a solution of 1·32 per cent. strength produces effects followed by death, and of which a solution of 0·66 per cent. injures plant growth considerably.

**Action on Insects.**—Amylic alcohol alone is less poisonous than its mixtures with soft soap. It does not kill the caterpillar of the cochylis. These mixtures have, however, a very categoric action on soft-skinned insects, such as plant lice and caterpillars, and are of universal use; they have a better action than aqueous insecticides, because they soften the insects touched. Used alone on the cankers of apple-trees produced by the woolly aphis they destroy it. Spraying with a mixture of water and 15 per cent. amyl alcohol has been used to remove from meadows the laying females of the cockchafer.

**Use.**—A great number of the insecticides of commerce are mixtures of amylic alcohol, soft soap, and an insecticide substance such as pyrethra powder, tobacco, etc. The following are the compositions of some of these insecticides :—

TABLE LXII.—*Showing the Composition of Nessler's Insecticides.*

| | Lb. | Lb. | Lb. |
|---|---|---|---|
| Soft soap | 4 | 30 | 5 |
| Amyl alcohol | 5 | 32 | 10 |
| Ordinary alcohol | 20 | — | 20 |
| Tobacco extract | 6 | — | — |
| Potassium sulphide | — | 2 | — |
| Water (in gallons) | 10 | 10 | — |

The following mixtures are also used as insecticides :—

TABLE LXIII.—*Showing Composition of Mixed Amyl Alcohol Insecticides.*

| | Lb. | Lb. |
|---|---|---|
| Green vitriol | 1 | — |
| Sulphate of alumina | — | 4 |
| Amyl alcohol | 5 | 5 |
| Water (in gallons) | 10 | 10 |

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[1] *Translator's Note.*—Amylic alcohol is a most unpleasant substance to handle. A piece of canvas or an old straw hat coated with a varnish in which amyl alcohol

An analogous insecticide is obtained thus: Dissolve 3 lb. of soft soap in 10 gallons of hot water, and add after cooling with constant stirring 6 lb. of ordinary alcohol, then 6 lb. of amyl alcohol; before making the mixture the insecticides are incorporated in the alcohol if they are insoluble in water, and in the soapy solution if they are soluble in the alkaline liquid. These preparations keep perfectly; when used they are diluted as circumstances may require. The different applications of these insecticides are detailed under Soap.

**Glycerine,** $CH_2OHCHOHCH_2OH$.—**Preparation.**—Glycerine is present in all natural fats chemically combined with fatty acids. It is a by-product of soap manufacture.

**Use.**—Glycerine is only mixed with insecticides and anticryptogamic solutions to increase their adherence to the leaves. It has been recommended chiefly by Mohr.

**Ether,** $C_2H_5.O.C_2H_5$.—**Definition.**—Ordinary ether, erroneously termed sulphuric ether, is the oxide of ethyl.

**Preparation.**—To 7 parts of ethyl alcohol there is added, in the cold, 10 parts of concentrated sulphuric acid; the mixture is heated in a flask to 140° C. and 95 per cent. alcohol is allowed to drop therein so as to keep the temperature constant. In these conditions alcohol is converted almost entirely into ether and water.

$$2C_2H_5OH = C_2H_5.O.C_2H_5 + H_2O.$$

**Properties.**—Ordinary ether is a very mobile liquid, volatile, and of a penetrating odour. It boils at 35·6° C. It dissolves in 10 parts of water. [Highly explosive.]

**Action on Plants.**—An atmosphere saturated with ether vapour does not lower the germinative capacity of dry seeds, but it only requires a small quantity, 3·7 cubic centimetres per 10 litres of air (3·7 cubic inches per 10,000 cubic inches), to kill moist seeds. Ether favours the assimilation of the plant in an analogous manner to chloroform, but whilst it takes 0·5—0·7 of the latter to stimulate this function, ether acts favourably in 5—6 per cent. doses. This action disappears when the ether is lower or higher than the figures indicated. There is also a fixed dose to stimulate the respiratory functions.

**Use.**—*Cochylis ambignella*, Hub. (cochylis of the vine); *Eudemis botrana* (eudemis or tortrix of the grape).—Audebert used with success against the caterpillars of these two butterflies the following liquid: Ordinary ether 10 lb., essence of absinth $1\frac{1}{2}$ lb., ammoniate of copper $8\frac{1}{2}$ lb., pure rosin 15 lb., carbonate of soda 15 lb., water 95 gallons. To prepare this liquid dissolve the rosin and the carbonate of soda in 6 gallons of water, boil until of a syrupy consistence, cool, remove the excess of liquid, redissolve in the necessary amount of water, add the ether and the essence of absinthe, and when the mixture is homogeneous

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has been used to dissolve the resin used in the manufacture of the varnish should drive off all insects from the neighbourhood. The least trace of amyl alcohol in the air causes coughing of a most irritating nature, and an insecticide in which amyl alcohol has been used can readily be detected by this means. As the boiling-point of amyl alcohol is some 32° C. higher than that of water, it will readily be seen that its irritating vapour is persistent if not permanent.

add the ammoniate of copper. The preparation should form a limped green liquid. This preparation is termed "Bordeaux insecticide." In 1902 more than 30 million stocks were treated with this insecticide, either by steeping the grapes or by a very fine jet. The amount consumed varies from 300—600 litres per hectare (26·4—52·8 gallons per acre). This preparation is recommended for the destruction of parasites in general, for it kills all caterpillars. Nobbe and Richter found that ether could replace carbon disulphide in the disinfection of the soil. They obtained by the disinfection of the soil by an ether emulsion a yield of 4·5 per cent. higher than that of the untreated plot, and they attribute this favourable result partly to the stimulating action of the small amounts of ether retained in the soil.

**Mercaptan,** $C_5H_2SH$.—**Preparation.**—By distilling sulphovinate of soda on the water-bath in presence of potassium hydrosulphide.

**Properties.**—Mercaptan is a colourless liquid with a very unpleasant alliaceous odour, boiling at 30° C. (86° F.) and slightly soluble in water.

**Use.**—Mouillefert and Rommier tried mercaptan to exterminate the phylloxera; 10 drops of mercaptan in a 1-litre flask killed the phylloxera in two days; tried on the large scale, by distributing in six holes dug round the infested stocks, a mixture of 12·5 cubic centimetres of mercaptan and 37·5 cubic centimetres of tar, the effect produced on the phylloxera was almost *nil.*

**Formic Aldehyde,** HCOH (**Formol, Formaline**).—**Preparation.**—By the oxidation of methyl alcohol vapours at a high temperature. It is manufactured commercially by the following process, due to Trillat. Methyl alcohol is heated in a copper jacketed pan. The vapours disengaged, mixed with air, are oxidized by passage over fragments of coke heated to a dull red. The products are afterwards rapidly abstracted by a vacuum at a more advanced stage of oxidation. The commercial concentrated product contains 40—42 per cent. of formic aldehyde. In medicine or agriculture this solution is called formol or formaline. Polymerized formol is also sold under the form of pastilles, which by heating disengage formol.

**Properties.**—Formol possesses a strong sharp odour; its vapour irritates mucous membranes, the conjunctive in particular. Formol is soluble in pure water up to 30 per cent., in presence of methyl alcohol up to 42 per cent. It has extremely remarkable antiseptic properties, much resembling those of corrosive sublimate. Like the latter it acts on albumen and arrests, by its contact, the movements and growth of micro-organisms.

**Action of Formol on Plants.**—Loew has pointed out its toxic action on plants, but formol does not appear to have this action in the doses in which it is used to combat plant diseases. Utilized almost exclusively to disinfect seed for sowing, it is especially from this point of view that it has been examined. Its vapours have almost the same action as its dilute solutions. The action of 0·1—0·2 per cent. solutions of formic aldehyde (0·25—0·5 of formaline) is hurtful both to cereal grains and leguminous seeds, for it retards germination. However, beet seeds suffer less. F. Bruning has examined the point, and got the following results with oats :—

TABLE LXIV.—*Showing Effect of Steeping Seed-oats in Formol Solutions on Germination.*

| Duration of action in minutes. | A. | | B. | |
|---|---|---|---|---|
| | Germinative capacity, per cent. | Germinative faculty, per cent. | Germinative capacity, per cent. | Germinative faculty, per cent. |
| 5 | 82 | 98 | 54 | 99 |
| 10 | 77 | 99 | 79 | 99 |
| 30 | 78 | 99 | 57 | 99 |
| Untreated | — | — | 80 | 98 |

A, seeds sown undried; B, seed air-dried for twenty-four hours before sowing. These results show that a 0·3 per cent. solution of formic aldehyde (= 0·75 per cent. of formol) does not act on the germinative faculty but solely on the germinative capacity; it therefore only retards germination without abolishing it. Cranefield has shown to what point the germinative capacity is diminished by treatment with formol, and has demonstrated the effect of the concentration of the formol bath (steep) on the latter.

TABLE LXV.—*Showing Effect of Twenty Minutes' Steeping in Formol Solutions of Various Strengths on the Germinative Capacity of Seed-corn. Water =* 94·5 *per cent.*

| Formic aldehyde, per cent. | Equal to formol, per cent. | Germinative capacity, per cent. | Formic aldehyde, per cent. | Equal to formol, per cent. | Germinative capacity, per cent. |
|---|---|---|---|---|---|
| 0·1 | 0·25 | 91·0 | 0·2 | 0·5 | 74·0 |
| 0·112 | 0·28 | 89·5 | 0·252 | 0·61 | 73·0 |
| 0·124 | 0·31 | 87·5 | 0·5 | 1·25 | 31·0 |
| 0·144 | 0·36 | 88·0 | 1·0 | 2·50 | 12·0 |
| 0·164 | 0·41 | 88·5 | | | |

Solutions of formol lower the germinative capacity of seeds the more formic aldehyde they contain. Table LXVI, giving the result of two

TABLE LXVI.—*Showing Effect of Duration of Steep in Formol Solutions on Germinative Faculty of Seed-corn.*

| Duration of steep. | Disinfectant. | Germinative faculty. | |
|---|---|---|---|
| | | A. | B. |
| 20 minutes | Solution of 0·25 per cent. formol, 40 per cent. . | 85 | 89 |
| 1 hour | „ 0·25 „ „ „ . | 92 | 87 |
| 2 hours | „ 0·25 „ „ „ . | 86·3 | 89 |
| 3 „ | „ 0·25 „ „ „ . | 88 | 93 |
| 24 „ | „ 0·26 „ „ „ . | 82 | 78 |
| 3 „ | Pure water . . . . . . . . | 93 | 90 |
| Untreated | . . . . . . . . . | 95 | 92 |

series of experiments, proves that the injurious action of formol does not depend on the duration of the steep.

If the seed-corn so disinfected be sown on the fields the effect of the treatment is visible during the first stage of germination, but after thirty days there is no difference. A 0·1—0·2 per cent. solution of formic aldehyde, say 0·2—0·5 per cent. of 40 per cent. formol, may be used with impunity to disinfect seed-corn.

**Action of Formol on Fungi.**—The surprising properties of formol, its action on micro-organisms, were recognised and examined by Trillat. He determined that its bactericidal capacity equalled that of corrosive sublimate, and that its extremely diffusible vapours are endowed with the same antiseptic properties. He believes that its action results from its property of rendering albuminous matter insoluble; formol acting on the protoplasm of the bacteria hardens it instantly, and they are thus unable to continue their evolution. Bardet agrees that formol acts in the same manner as on gelatine, on the envelopes of bacteria and on the spores of fungi and renders them unfit to discharge vital functions. It has, on the other hand, been seen that corrosive sublimate acts in a similar manner on albuminous bodies. Numerous experiments made on different bacteria show that a dose of 1 in 10,000 to 1 in 20,000 of formol generally suffices to sterilize culture media and to render bacteria sterile; it takes at least 1 in 1000 of formol to kill them. *Penicillium* fungi and *Aspergillus* algæ behave similarly, according to the experiments of Trillat. A solution of 1 in 10,000, or the ambient air containing 1 in 20,000, prevents the development of young spores. These are the doses of corrosive sublimate recommended as sufficient to prevent the germination of the spores of different parasitic fungi. The action of formol on the spores of cryptogamic parasites ought, therefore, to be about the same as that of corrosive sublimate. Although the remarkable properties of formol were known earlier, it was not until 1896 that Geuther tried to use this product in agriculture, and after fortunate results recommended it for disinfecting seed-corn in place of hot water or blue virol. The experiments made with this end in view show that the dose of 1 in 10,000, which stops the development of spores for some time, does not suffice to completely disinfect seed-corn, and to prevent fungi from subsequently attacking the plant. Hecke observed as regards the spores of *Ustilago crameri*, that they only remained inactive for six to eight days after the treatment, and that the evolution of the disease was only retarded, which delay is often sufficient to guarantee the young plant. The dose of 1 in 1000 suffices, on the other hand, to disinfect the seed completely.

The following are, moreover, the results of different researches on this subject.

McAlpine has compared the action of blue vitriol, corrosive sublimate, and formol on the spores of *Tilletia* and obtained no infested ears (1) by immersion for one minute in a 2·4 per cent. solution of blue vitriol; (2) by immersion for three minutes in a 0·12 per cent. solution of corrosive sublimate; (3) by immersion for ten minutes in a solution of formic aldehyde 0·05 per cent. (0·125 per cent. of formaline), whilst the untreated plot gave 95 per cent. of rusty ears. These doses thus completely disinfect seed-corn. Moore made the following experiments on oats and obtained :—

TABLE LXVII.—*Showing Effect on Oat Crop of Steeping Seed-oats in Solutions of Formol of Different Strength and for Ten Minutes up to One Hour.*

| Duration of steep. | Formol, 100 per cent. | Diseased ears, per cent. |
|---|---|---|
| 10 minutes | 0·1 (1 lb. formaline in 40 gals. water) | 1 |
| 20 ,, | 0·1 (1 ,, ,, ,, ,, ) | 0 |
| 20 ,, | 0·05 (1 ,, ,, 80 ,, ,, ) | 5 |
| 40 ,, | 0·05 (1 ,, ,, ,, ,, ) | 4·3 |
| 60 ,, | 0·025 (1 ,, ,, 160 ,, ,, ) | 20·0 |

Hecke made the curious observation that it sufficed to wash the spores after treatment to redouble all their vigour. Spores of *Ustilago crameri* steeped fifteen minutes in a formol solution of 0·4 per cent. and unwashed, did not germinate in thirty days, but they germinated normally in twelve days if washed after treatment. Treatment with formol even in large doses does not kill the spores if they are afterwards washed with water. The spores of *Ustilago crameri* are only killed by an immersion of one hour in a 1 per cent. bath of formol or three hours in a 0·5 per cent. bath of formol. To disinfect seed-corn and sufficiently retard the development of spores, an immersion of fifteen minutes in 0·4 per cent. of formol, of one hour in 0·2 per cent., and three hours in 0·1 per cent. suffices.

**Action of Formol on Insects.**—Insects withstand formol better than fungi; coccides are not killed by formol vapour after two days' action. Solutions are without action on plant lice, or the caterpillars of cochylis.

**Use.**—*Oospora scabies*, Taxter (potato scab); *Rhizoctinia Solani* (potato pox and rot of the stem of the potato); *Phytophthora infestans*, de By. (potato disease).—The spores of these fungi adhere to the seed potatoes and most often propagate the disease. To prevent this, the soil and the seed potatoes were disinfected by formol, and the results obtained were satisfactory. According to some experiments, disinfection by formol is as effective as by corrosive sublimate. The formol solutions recommended vary from 0·33—0·4 per cent. of formol, say 0·16—0·13 per cent. of formic aldehyde. Steeping should last two hours. The following is a convenient method of working: Immerse the uncut tubers for two hours in a bath consisting of 4 lb. of 40 per cent. formol in 100 gallons of water, dry them, convey them to the field in disinfected sacks and plant them. Some workers recommend the disinfection of tubers by formol vapour generated by heating formaline pastilles in a closed space. Delacroix advises against *Bacillus solanacearum* the disinfection of the soil by a 0·13 per cent. solution of formol in the proportion of 10—12 litres (2·2—2·64 gallons) per square metre and steeping the tubers for two hours in a solution of the same strength. Against *Rhizoctinia* of the asparagus disinfection of the soil with 60 grammes (about 2 oz.) per square metre. Potatoes so treated only gave 3 per cent. of diseased stems, the untreated gave, on the contrary, 40 per cent.

*Botrytis cinerea* (grey rot of the vine).—Tubeuf recommends formol vapour in a closed space against this fungus. It is possible that on the large scale formol solutions would act energetically against this mould. If applied on grapes the moment the disease appears, the effect would, without doubt, be salutary, for Trillat has shown the energetic action of formol on the *Penicillium* mould, a closely allied species.

*Microsphæra grossullariæ*, Wallr. (gooseberry blight). Close records that a formol solution of 0·08—0·18 per cent. gives as good results as potassium sulphide. It is necessary to begin the treatment as soon as the disease appears.

*Fusarium dianthi*, Pr. et Del.—Delacroix having found that formol vapours killed the *chlamydospores* of this fungus advised the disinfection of the soil by formol to prevent this disease.

*Fusarium nov. sp.*,[1] Bolley (flax disease).—Bolley obtained very good results by disinfecting the seed for sowing by immersion in a formol solution of 0·5 per cent. (0·2 per cent. formic aldehyde).

*Tilletia and Ustilago* (bunt and smut of grain crops).—The disinfection of seed-corn by formol was invented by Geuther. It is now recognized as far superior to the other methods. It results from numerous trials in this direction that 0·25 per cent. formol solutions (0·1 per cent. formic aldehyde) are strong enough and that fifteen minutes' immersion suffices to disinfect the seed-corn completely. By this treatment crops can be obtained without any diseased ears. It is essential not to wash the grain after treatment, for as Hecke has shown washing reimparts all their vitality to the spores and thus totally annuls the effect of the treatment. The seed is dried after immersion or planted immediately after simple draining and whilst still moist. Tubeuf and Neger have examined the disinfection of seed-corn in a closed space by formol vapour and obtained the same results as with solutions, but the grain must remain at least five hours in an atmosphere containing formol. It suffices to heat a tablet of formaline on a spirit lamp, and close in the space. Bedford compared the action of Bordeaux bouillie made from 2 per cent. of blue vitriol and 2 per cent. of lime with that of a formaline solution of 0·2—0·3 per cent. The results showed the superiority of the formaline.

These results were submitted to a regular control in Canada, and found exact. Bedford considers that an immersion of five minutes in a formaline solution of 0·3 per cent suffices to guarantee crops completely against rust diseases. The seed is sown immediately after steeping. Selby recommends steeping seed-wheat infested with *Tilletia* spores first in water, then to remove the floating ones, then draw off the water and replace by a 0·2 per cent. of formaline. Bolley advises a mixture of formol and corrosive sublimate as indisputably superior to all other disinfectants. It would always give good results.

*Ustilago crameri* (smut of millet).—Hecke examined the effect of

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[1] FUSARIUM NOV. SP. (flax disease).—The exhaustion of the soil in flax cultivation is due, according to the researches of Bolley, to the presence of a fungus which, in attacking flax plants, weakens them and eventually causes them to perish: growth is stopped, the shoots fade and finally dry up.

TABLE LXVIII.—*Showing the Results of Growing Oats from Undisinfected Seed and from Seed Disinfected by 2 Per Cent. Bordeaux Bouillie, and from Seed Disinfected by 0·2 Per Cent. and 0·3 Per Cent. Solutions of Formaline.*

| Variety of oats. | Treatment. | Healthy ears. | Diseased ears. |
|---|---|---|---|
| Mortgage Lifter . | Nil | 249 | 29 |
| Doncaster Price . | ,, | 365 | 49 |
| Flying Scotsman . | ,, | 392 | 52 |
| Mortgage Lifter . | Bordeaux bouillie, 2 per cent. | 298 | 8 |
| Doncaster Price . | ,, ,, | 322 | 32 |
| Flying Scotsman . | ,, ,, | 295 | 9 |
| Mortgage Lifter . | Formaline, 0·2 per cent. | 386 | 0 |
| Doncaster Price . | ,, ,, | 265 | 0 |
| Flying Scotsman . | ,, ,, | 298 | 0 |
| Mortgage Lifter . | Formaline, 0·3 per cent. | 188 | 0 |
| Doncaster Price . | ,, ,, | 255 | 0 |
| Flying Scotsman . | ,, ,, | 262 | 0 |

TABLE LXIX.—*Showing the Results of Growing Oats from Undisinfected Seed and from Seed Disinfected by 2 Per Cent. Bordeaux Bouillie, and from Seed Disinfected by 0·2 Per Cent. and 0·3 Per Cent. Solutions of Formaline.*

| Variety of oats. | Treatment. | Duration of steep. | Sound ears. | Diseased ears. |
|---|---|---|---|---|
| Doncaster Price | Nil | — | 163 | 142 |
| ,, ,, | Bordeaux bouillie, 2 per cent. | 5 minutes | 236 | 98 |
| ,, ,, | ,, ,, | 10 ,, | 175 | 100 |
| ,, ,, | Formaline, 0·3 per cent. | 5 ,, | 291 | 0 |
| ,, ,, | ,, ,, | 10 ,, | 386 | 0 |
| ,, ,, | ,, ,, | 30 ,, | 325 | 0 |

TABLE LXX.—*Showing the Effect of Solutions of Formaline, Corrosive Sublimate, Oil of Vitriol, Blue Vitriol on the Germinative Capacity of Millet Seed and the Spores of* Ustilago crameri.

| Treatment. | Strength, per cent. | Duration of action. | Effect on seed. | | Spores germinated. | | |
|---|---|---|---|---|---|---|---|
| | | | Definitive germination, per cent. | Germinative force, per cent. | After one day. | After two days. | After twelve days. |
| Formaline . . | 0·25 | 2¼ hours | 81·5 | 89 | Nil | Nil | Some |
| ,, . . | 0·25 | 6 ,, | 74·0 | 88 | ,, | ,, | Nil |
| ,, . . | 0·5 | 2¼ ,, | 72·5 | 87 | ,, | ,, | ,, |
| ,, . . | 0·5 | 6 ,, | 67 | 84·5 | ,, | ,, | ,, |
| Corrosive sublimate | 0·1 | 30 minutes | 69 | 88 | ,, | ,, | ,, |
| ,, ,, | 0·2 | 30 ,, | 69 | 88 | ,, | ,, | ,, |
| Sulphuric acid . | 0·5 | 14 hours | 79 | 83 | A few | Great number | Great number |
| Blue vitriol . . | 0·5 | 14 ,, | 75·5 | 88·5 | Nil | Nil | Nil |
| Untreated . . | — | — | 74 | 89 | Great number | Great number | Great number |

different disinfectants on the spores of this smut. Millet being very sensitive to hot water, the latter cannot be recommended as treatment; disinfection by formol in 0·1 per cent. solution is therefore of great importance.

To show the good effect of formol as a disinfectant, Hecke submitted a portion of seed-millet to various treatments, and only collected for sowing the very rusty seed which floated. In these conditions he obtained in the open field the following result:—

TABLE LXXI.—*Showing the Effect of Certain Disinfecting Fluids on the Crop Produced from the Rusty Seed-corn which Floats on the Fluid.*

| Treatment. | Strength per cent. | Duration of steep. | Number of diseased ears. | Diseased ears, per cent. |
|---|---|---|---|---|
| Sulphuric acid . . | 0·5 | 14 hours | 898 | 81·6 |
| Blue vitriol . . | 0·5 | ,, ,, | 54 | 4·9 |
| Formaline . . | 0·5 | 5½ ,, | 11 | 1·0 |
| Untreated . . | — | — | 1100 | — |

Hecke after many trials, which need not be discussed, believed in the efficiency of formol as a disinfectant for seed-millet and in its superiority to the usual disinfectant if the grains are steeped for fifteen minutes in 0·5 per cent. solution of formaline, or for one hour in 0·25 per cent. solution of formaline, or for three hours in 0·125 per cent. solution of formaline.

*Ustilago panici miliacei* behaves like *Ustilago crameri.*

*Urocystes cepulæ*, Frost (onion smut).—Selby made experiments to overcome this disease, and it was chiefly by formol and lime that he diminished it by introducing these products in the soil at the time when the onion is sown.

TABLE LXXII.—*Showing the Action of Formol and Lime and Mixtures thereof on Onion Rust.*

| Treatment. | Rust found. | Increase of onion crop, per cent. |
|---|---|---|
| Quicklime, 33 bushels per acre . . | Much | 32·3 |
| ,, 66 ,, ,, . . | A little | 65·2 |
| Formaline solution, 0·375 per cent. . . | Very little | 113 |
| ,, ,, 0·75 ,, . . | Infinitesimal | 119 |
| Quicklime, 120 bushels per acre . . | Nil | 120·6 |
| ,, 66 bushels per acre<br>Formaline solution, 0·375 per cent. . | Nil | 132·8 |

The quantity of formaline of 0·375 per cent. and of 0·75 per cent. which is used varies from 4675—6540 litres per hectare (411 gallons per acre to 575·4 gallons per acre). The lime is regularly incorporated with the soil; before sowing the onions the formaline is run mechanically on to the seeds whilst the latter are being sown by the drilling machine.

**Practical Method of Disinfecting Seed-corn.**—An 88-gallon vat is filled with water and about 1 quarter gallon of 40 per cent. formol added. Two bags containing $\frac{1}{2}$ cwt. of the grain to be disinfected are then placed therein. A man for fifteen minutes unceasingly turns the bags in the liquid in such a way that each bag comes in contact with the formol. The sacks are raised and allowed to drain on two bars laid over a low vat placed alongside the big vat. The grain is then placed on the floor of a heated spot and dried at a temperature not above 30° C. (86° F.), shovelling them until dry. By this method 4 metric tons of grain may be disinfected in a day with three vats and a floor of 20 square metres (24 square yards). Needless to say, drying may be done in the open air and in the sun when a proper space is not at disposal.

The pickling of seed wheat by a solution of formaline has been tried against bunt on a large scale and found reliable. (Formaline is a liquid containing approximately 40 per cent. of formaldehyde gas in solution.) The British Ministry of Agriculture recommends the use of this, the solution being at the rate of 1 part of formaline to 320 parts of water (*i.e.*, 1 pint of formaline to 40 gallons of water). It has been found that complete control of bunt was secured by using formaline at the rate of 1 pint to 60 gallons of water. From one to two gallons of the solution should be sufficient for four bushels of wheat. It should be slowly sprinkled or sprayed over the grain, which should be stirred, so that all the grains become thoroughly moistened. The solution should not be allowed to form pools under the heap of grain. The seed should then be placed in a heap and covered with sacks soaked in the solution, but not too wet. The seed may then be left for four hours, after which it should be spread out to dry on a clean floor which has been disinfected by formaline solution and allowed to dry before the seed is spread upon it. The sacks in which the seed is to be placed should be treated with formaline solution in the same way, or boiled in water and subsequently dried. Seed wheat treated as advised suffers slightly in germination, and should therefore be sown a little thicker than is usual.

*House Flies.*—Formaldehyde, in solutions of various strengths, has been recommended from time to time for the destruction of flies. It has been found in the U.S.A. that the best results are obtained with a solution containing 1 per cent. of the formaldehyde or $2\frac{1}{2}$ per cent. of the 40 per cent. solution, which is the form in which it is usually sold. Concentrations greater or less than this are less efficient, although the efficiency does not fall off very rapidly down to a half per cent. solution. Solutions stronger than 1 per cent. apparently repel the flies by their odour, although there is evidence that the odour of the 1 per cent. solution is slightly attractive—that is, the flies prefer it to plain water. For household use the solution may be prepared by the addition of 3 teaspoonfuls of 40 per cent. solution of formaldehyde to a pint of water. Nearly fill a glass tumbler with the solution, place over this a piece of blotting paper cut to circular form and somewhat larger in diameter than the tumbler, and over this invert a saucer. Invert the whole device and insert a match or toothpick under the edge of the tumbler to allow access of air. The blotting paper will remain in the proper moist condition until the entire contents of the tumbler have been used and the strength of the formaldehyde solution will be maintained. A little sugar sprinkled upon the paper will increase the attractiveness of the poison for the flies.

**Acetic Acid,** $CH_3 \cdot CO \cdot HO$.—**Preparation.**—Acetic acid results from the oxidation of ethyl alcohol. The acetification of the alcohol is due to its oxidation, under the influence of an aerobic ferment, *Mycoderma aceti*, or mother of vinegar, and the oxygen of the air. It is prepared commercially by letting wine flow slowly into casks filled with wood shavings " sown " with mycoderma, and traversed from below upwards by a slight current of air. The alcohol oxidizes rapidly at 30° C. Acetic acid is also a product of the distillation of wood.

**Properties.**—Acetic acid is a colourless liquid soluble in water and alcohol, and boiling at 118° C. Vinegar, which only contains about 10 per cent. of acetic acid, is used to preserve fruit.[1]

**Action on Fungi and their Spores.**—Fungi spores are very sensitive to acetic acid (Wuthrich). Dilute acetic acid (0·06 per cent.) still destroys the zoospores of *Phytophthora infestans*, de By., and acts very unfavourably on the germination of the conidia of *Peronospora viticola*, de By. The spores of *Ustilago carbo* do not germinate after steeping in acid of 0·06 per cent.; the uredospores of *Puccinia graminis*, although very sensitive to a solution of 0·06 per cent., are only destroyed by acid of 0·6 per cent. The latter results agree with those obtained by Hitchcock and Carleton on *Puccinia coronata*. These spores do not germinate after steeping in acid of 0·1 per cent.

**Use.**—*Coryneum Beyerinckii* (gum of trees with stoned fruits, *Nectria ditissima*).—Muller advises to overcome the gum of fruit trees by the following treatment. After having removed the bark, scraped and planed the wound with the knife, a rag, drenched with 50 per cent. acetic acid, is introduced into the wound and covered with a layer of grafting mastic.

**Oxalic Acid,** $COOH \cdot COOH$.—**Preparation.**—By oxidizing wood sawdust mixed with a concentrated alkaline solution and heated to 250° C. (482° F.) in wrought-iron cylinders. The mass obtained is treated with water, and milk of lime added. Oxalate of lime is precipitated and collected on a filter. The precipitate is decomposed by dilute sulphuric acid, filtered, and the solution evaporated to crystallizing point.

**Properties.**—Oxalic acid forms white crystals soluble in 10 parts of water at 20° C. and in alcohol.

**Action on Fungi.**—The effect of oxalic acid on the spores of fungi has been examined by Wuthrich. This acid behaves very like acetic acid. The conidia of *Peronospora viticola*, de By., and of *Phytophthora infestans*, do not germinate in an oxalic acid solution of 0·063 per cent.; the movements of the zoospores of this latter fungus are arrested, as well as their germination, by a 0·0063 per cent. solution. The spores of *Ustilago carbo* behave like the conidia of *Peronospora*; however, the uredospores of *Puccinia graminis* are more resistant and are not killed by a 0·63 per cent. solution.

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[1] *Translator's Note.*—The author here refers no doubt to the wine vinegar of France; the percentage in British malt vinegar is often less than half that given here.

**Use.**—*Nectria ditissima*, Tul. (canker of the pear-tree).—Ouvray advises the use of oxalic acid to overcome the canker of fruit trees. Clean the wound with a grafting knife, remove everything which is torn or destroyed, then rub the wound several times with sorrel or oxalic acid, then cover the wound with mastic or tallow to keep out the air.

*Schizoneura lanigera*, Hausm. (woolly aphis).—Oxalic acid appears to be a specific against this aphis, for many scientific observers attest its good effects. It is as energetic as Nessler's insecticide. A solution of 1—1·6 per cent. pure or mixed with a little soft soap, is used with the brush on the colonies of woolly aphis, for the first time in autumn after the ripening of the fruit, a second time eight to ten days later, and a third time in the spring.

# CHAPTER XX

## CARBON COMPOUNDS (*continued*)—OILS AND FATS—SOAPS—HARD SOAP —SOFT SOAP—WHALE OIL SOAP—FISH OIL SOAP

**Natural Fats.**—**Preparation.**—Oils and fats are chemical compounds of glycerine and fatty acids. They are found, in nature, both in plants and in animals. They are extracted either by hot or cold pressure between plates, or heated millstones, or by an appropriate solvent—ether, carbon disulphide, chloroform, benzine, petroleum spirit, etc.

**Properties.**—Oils are insoluble in water; they oxidise in the air, resinifying in so doing.

*Colza oil*, extracted from seeds of *Brassica campestris*—D = 0·913 at 15° C., solidifies at 6·2° C.

*Poppy oil*, extracted from seeds of *Papaver somniferum*—D = 0·925, congeals at 19° C.

*Olive oil*, obtained by hot crushing of ripe olives—D = 0·919 at 12° C., congeals above 0° C.

*Linseed oil*, extracted from the seeds of *Linum usitatissimum*, has a density of 0·939 at 12° C.

*Whale oil*, extracted from certain organs of the whale—D = 0·927, concretes at 0° C.

**Action on Plants.**—Vegetable respiration being carried on in the leaves, these organs should remain in contact with the air so that they may fulfil their physiological functions. The application of oil on the leaves is therefore injurious to the plant. The pure oils themselves, applied uniformly on the trunk of a tree, have an injurious effect on the health of the plant. Mouillefert found, in fact, that young vines are killed if the greater part of their roots is covered with oil.

**Action on Insects.**—Although the action of oils on insects is mechanical, they are as efficient as poisonous insecticides. The oil penetrates everywhere, and by invading the respiratory organs asphyxiates the insects. Eggs covered with a layer of oil also die, because the exchange of gases through the membrane of the egg can no longer be carried on.

**Use.**—Oils are used in the pure state or as emulsions with pure or soapy water. The emulsions are prepared like emulsions of petroleum with water.

*Silpha opaca* (beet carrion beetle).—Brocchi overcomes the ravages of this insect in the North by an emulsion of soft soap 1 lb., rape oil or poppy oil 15 lb., water 84 lb. Fouquier d'Herouel describes its good effects when sprayed on and between the plants to be protected. One workman treats a hectare (2½ acres) in nine hours.

*Atomaria linearis*, Steph.—This parasite is overcome in the same way as the beet silph.

*Cochylis ambignella*, Hubn. (cochylis of the vine).—Roy advises to asphyxiate the caterpillars of this butterfly by dropping one to two drops of colza oil in each of the silky nests. Muth describes the excellent results obtained against these caterpillars at the Oppenheim School of Viticulture by the use of olive, sesame, and colza oils. The lantern traps in use in Switzerland, for trapping butterflies at night, are surrounded with a plate which contains a bird-lime consisting of white pitch 10 lb., linseed oil 5 lb., olive oil 6 lb., turps 5 lb. Debray advises to bark the tree with the Sabate glove, and then to coat them with oil extracted from sulphuretted colza oil cakes [ ? by carbon disulphide]. It takes 1 litre of oil for twenty stocks.

*Caterpillars and Eggs of Lepidoptera.*—Oils and their emulsions with soapy water are, in general, of indisputable efficiency on caterpillars and eggs, and are employed in many cases. Saunier recommends an emulsion prepared in the following way: Dissolve 2 grammes of carbonate of soda in 1 litre of water, and then add 30 grammes of linseed oil; stir until formation of a homogeneous emulsion. The nests of the caterpillars are sprayed by a hand syringe or by a spraying machine. The eggs deposited on the surface of the branches are destroyed by coating with the pure oil.

*Formica* (ants).—Oil emulsions are used to destroy ants: Oil 30 lb., carbonate of soda 5 lb., in 100 gallons of water, or better still, olive oil alone. It is especially used to destroy the ants which climb along the branches and trunks of trees.

*Gryllotalpa vulgaris* (mole cricket).—Ratzeburg in 1847 advised to inject oil into the tunnels of the mole cricket and to sprinkle with water. Before the preparation of the beds, whilst the bed is bare, the tunnel openings are inspected and a few drops of oil run into each, then water from a water-can.

*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—Mouillefert has shown that colza, poppy, olive, and nut oils kill the phylloxera by contact with the greatest of ease. Their use cannot, however, be adopted on the large scale, as they kill the plant too readily.

Pollier's process against phylloxera, which consisted in coating the stems with an emulsion of whale oil and petroleum, did not give satisfactory results.

*Aphides* (green lice).—To kill the eggs of these green lice deposited in lichens along the trunk or on the end of branches it suffices, according to Taschenberg, to rub these spots with oil.

*Schizoneura lanigera*, Hausm. (woolly aphis).—Oils are especially used to destroy this aphis, as they easily penetrate its wool and asphyxiate it. The oil should only be applied to small surfaces, nodes, cankers, holes. Muhlberg advises to coat the cankers with fish oil, with burning oil, or a mixture of burning oil and petroleum. Muhlers advises to brush the hotbeds of infection with oil or fat, and to repeat this treatment every fifteen days. Cirbert advises to rub the infested places with a rag dipped in olive oil. Oil is currently used in Italy against this aphis. Weiss advises to cut out the cankers and to treat them with insecticides, and then to cover the wounds with oil paint, which kills by asphyxia any aphis which might escape, and which protects the wounds very efficiently. Henri advises to drench the swellings on the trunk and the branches with a mixture prepared in the following manner: Crush together alum 5 oz., sal ammoniac 5 oz., and mix with sulphuric acid 3 oz., colza oil 100 oz. (all avoirdupois). According to Kraft, it suffices to plug the wounds produced by the woolly aphis with a mastic made by mixing plaster of paris and linseed oil. Ouvray recommends as an excellent medium for destroying the woolly aphis, burning oil, in which 5 lb. of naphthalene has been incorporated per 10 gallons. At the fall of the leaf the diseased apple-trees are brushed, the nodosities cut off, and coated with the naphthalinated oil, taking care not to touch the buds. In March or April the tree is again inspected, and if need be, the spots recently invaded are plugged with the naphthalinated oil, applied by the brush.

*Coccides* (cochineals).—Cochineals, kermes, etc., may be killed in the same way as the woolly aphis, by oils and their emulsions with soap, or with petroleum. It is only to be feared that the too large surfaces, which it is often necessary to cover, may render the treatment injurious to the plant. This drawback disappears, according to Reh, if the oils are used as emulsions with soap or petroleum. Excellent results are got, according to him, with an emulsion of soft soap 20 lb., vegetable oil 15 lb., petroleum 10 lb., water 6 gallons. In America the San José louse is overcome with whale oil and fish oil.

*Lepus cuniculus*, L. (rabbit); *Lepus europæus*, L. (hare).—Putrid fish or animal oil protects crops and fruit trees. The bottom of the tree may be coated, or the property surrounded by a fence consisting of three cords dipped in this stinking oil, placed 8 inches from each other. The leporides fear this strong smell, much resembling the smell of its natural enemies, the ferret, the martin, and the fox.

**Soaps** are salts formed by the combination of a base with the fatty acids present in oils and fats. All vegetable and animal oils and fats yield soap with alkalies, and with metallic oxides generally. Their physical properties depend chiefly on the base used. Soaps made from alkaline metallic oxides are alone soluble in distilled water; those made from the oxides of other metals, lime or copper soap, for example, are, on the contrary, insoluble in water. Amongst soaps made from alkalies, hard soda soaps must be differentiated from soft potash soaps.

**Preparation.**—1. *Hard Soaps.*—They consist generally of the soda salts of margaric [palmitic], stearic, and oleic acids; *Marseilles* soap is the type of this sort. It is made by saponifying vegetable oils with caustic soda. Glycerine is formed along with the soap, and is eliminated in the mother liquor. In a large wrought-iron pan caustic soda lye of 10° Bé. is heated, and the oil to be saponified run in gradually. When the bulk is combined, the saponification is finished by adding lye of 20° Bé. Boiling is continued until the whole is homogeneous. The soap is then separated from the water by adding weak salted lye. The soap which floats is separated from the mother liquor. After complete boiling in fresh salt lye, the preparation of the soap is finished.

2. *Soft Soaps.*—They consist of the potash salts of the most diverse fatty acids, for all oils are used in their preparation.

According to the British Ministry of Agriculture, not less than 95 per cent. of the total alkali present in soft—that is, potash—soap sold for spraying purposes should consist of potash.

(*a*) *Whale Oil Soap.*—The salt of doeglic acid of whale oil. This soap is gelatinous, and but slightly soluble in water.

(*b*) *Fish Oil Soaps.*—The oils obtained by boiling decomposing herrings and other sea fish are much used in America for the preparation of soap intented to be used against parasitic fungi. Sixty pounds of caustic potash are boiled in 100 gallons of rain water, and 19 gallons of cod oil or herring oil. After two hours' boiling, the soap is finished. The soaps obtained are semi-solid.

[Addendum (1925) *re* Marine-oil Soaps: Soaps of this class are widely used as insecticides for spraying plants and trees, because they are believed to possess greater toxicity than other soaps against plant parasites, due to the nature of the oil which they are made of. Some entomologists, however, believe that marine-oil soaps are not any more destructive to insects than ordinary soap would be under the same conditions, although judging from the large quantities employed in this country for agricultural purposes it is probable that good results attend their use. These soaps are dark brown, fairly solid, with a strong and unpleasant fishy odour. The most important of the group is "whale oil soap," though soaps made from other fish oils appear to be equally effective. In the past it was customary to call all the soaps made from marine oils by the trade name of "whale oil soap," but now, to conform with the United States Insecticide Law, only those actually made from whale oil can be so named, while the others are designated as "fish oil soaps." The oil used as soap stock varies principally with the locality in which the soap is made. On the Pacific Coast fish oil soap is usually made from salmon oil, herring oil, and sometimes seal oil, while on the Atlantic Coast menhaden oil is used. Both Atlantic and Pacific whale oil are employed. The oils are usually prepared from the fish in question by disintegrating either the entire body, or the scraps which are to be used, by boiling in water stirred by live steam. The oil rises to the surface and is then removed, while the pulpy residue is subjected to a pressing process, whereby the last traces of oil are obtained. These pressings are very frequently employed in the manufacture of fish oil soaps, which then contain quantities of fish tissue. The fish oil soaps are usually sodium soaps, although a potash soap is far preferable, owing to the ease with which it can be mixed with water. The alkali is slightly in excess, about 2 per cent. of free alkali being frequently found on analysis. The water content of a good sodium soap should not exceed 15 per cent., while for a potash soap perhaps double this amount may be allowed. All marine-oil soaps are liable to adulteration with rosin. This, however, can easily be detected by chemical tests. Whale oil soaps are also apt to be adulterated, in that they are not made entirely of whale oil, but contain admixtures of other marine oils, particularly seal oil. These admixtures are practically impossible to detect chemically.]

(*c*) *Black Soap, Green Soap.*—These have a very analogous composition, they are the ordinary soft or potassic soaps. These soaps are gelatinous and soft, containing a great excess of lye and almost all the glycerine. They are thus very caustic, and act like feeble alkalies. They are obtained by boiling caustic potash chiefly with linseed, colza, and hemp-seed oil soap. The solutions are evaporated to a suitable consistency. American arboriculturists prepare a cheap and efficient soap by boiling together in 10 gallons of water, 12 lb. of lard, and 12 lb. of carbonate of potash. During boiling a milk of lime containing 5 per cent. lime is added. Before using it to coat trees 1 part of it is diluted with 2 parts of hot water. The bark of the trees covered with this soap always remains fine and smooth.

**Insecticide Preparations.**—Soap strengthens the action of certain insecticides. It is thus often mixed with the most diverse organic insecticides to form preparations capable of drenching the insects and bringing the poisons in contact with them better than aqueous solutions do. Soap emulsions are made with petroleum, benzine, carbon disulphide, and mixtures with ethyl alcohol, amyl alcohol, and quassia.

**Composition and Preparation of a Few Soap Insecticides.**—1. Macerate in water for twenty-four hours 1½ lb. of quassia; boil and mix the extract with 2½ lb. of soft soap in 10 gallons of water.

2. Pour 2 gallons of boiling water on 3 lb. of quassia chips, macerate twenty-four hours, add 5 lb. of soft soap in 2 gallons of water.

3. Emulsify 1 lb. of soft soap in 20 gallons of water with 1 lb. of carbon disulphide.

4. Emulsify 1 lb. of soft soap in 20 gallons of water with 1 lb. of petroleum.

5. Emulsify 1 lb. of soft soap in 20 gallons of water, 1 lb of carbon disulphide, and 1 lb. of petroleum.

6. Emulsify 5 lb. of amyl alcohol, 5 lb. of a concentrated alcohol solution of soap, 10 lb. of carbon disulphide, and 5 lb. of petroleum, in 100 gallons of water.

Emulsions Nos. 3 to 6 have been used with success at the Phytopathological Institute of Pisa.

7. Dissolve 3 lb. of soft soap in rain water, add 6 lb. of amyl alcohol, and make up to 10 gallons with rain water.

8. Dissolve 5 lb. of soft soap in 6½ gallons of water, add thereto 2 gallons of ordinary 90 per cent. alcohol and 1 gallon of amylic alcohol.

9. Infuse 3 lb. of tobacco for some time in 5 lb. of amyl alcohol, and 2 lb. of ordinary alcohol; add a solution of 4 lb. of soft soap, then make the whole up to 10 gallons.

These emulsions cannot be further dwelt upon here, each one will be described under the heading of the insecticide with which it is mixed.

**Insecticide Petroleum Soap.**—Saponify Ceylon coconut oil (20 parts) with caustic soda lye (12 parts), and stir in petroleum (3—5 parts).

**Action of Soap on Plants.**—Soaps are more injurious to trees the more caustic alkali and alkaline carbonates they contain. Solutions of Marseilles soap (hard soap) are less injurious than soft soap; the latter becomes injurious, according to plant treated, from 0·66 per cent.; it is dangerous to flowers from 1·32—2·5 per cent., for soapy sprayings prevent them from producing fruits; finally, it attacks the skin of stone fruit, and injures the leaves when tender. Used in winter of great strength (18—24 per cent.) soap renders the trees sterile; this is not the case with 6—12 per cent. solutions, except for the peach. Mixtures of soap and alcohol are slightly more injurious than aqueous solutions of soap, and when concentrated may kill the tree, but it is more especially mixtures containing tobacco which are dangerous and should be used with care.

**Action on Insects.**—Soap in solution acts energetically on soft-skinned insects and their larvæ. A 2 per cent. solution acts on caterpillars, larvæ of wire-worms, etc. Strong solutions of soap also act on protected insects, such as the coccides. Marlatt found that, used on trees in winter, a 24 per cent. solution of ordinary white soap killed more than 97 per cent. of the San José louse; an 18 per cent. solution killed more than 95 per cent.; a 12 per cent. solution more than 90 per cent.; a 6 per cent. solution more than 20 per cent.; and a 3 per cent. solution more than 10 per cent. Fish oil soaps are less energetic. An 18 per cent. solution only kills 50—75 per cent.; and a 12 per cent. solution only 20 per cent. Whale oil soap solutions of 20—30 per cent. kill 90—100 per cent. of San José louse. In these mixtures soap, whilst an insecticide, generally only acts by bringing the parasites in better contact with the insecticide and by increasing its adherence.

**Use.**—To dissolve the soap, or dilute preparations containing soap, it is well only to use rain or distilled water, to prevent the lime of ordinary water from precipitating lime soaps, which encrust the spraying machines.

**Cryptogamic Diseases.**—*Sphærotheca pannosa* (rose mildew).—To overcome this fungus use a 2 per cent. solution of soft soap.

*Mildew of Phlox Drummondii and of Verbenas.*—Halsted and Kelsey overcome this disease by a solution of 3 lb. of rosin [? soap] in 10 gallons of water. The plants were sprayed twenty-six times from 27 November to 1 April. The action of an emulsion of petroleum 3 gallons, rosin soap 2 lb., water 100 gallons, was much more efficient, even when diluted three times further.

**Insects.**—*Tomicus dispar, Bostrichus dispar* (the apple bark beetle).—To destroy eggs of this insect deposited on the trunk of fruit trees and branches a 25 per cent. solution of soft soap is used in Canada.

*Oryctes nasicornis*, L. (rhinoceros).—To destroy larvæ, water soil around stem with 2—3 per cent. solution of soft soap (Targioni-Tozzetti).

*Elaterides* (wire-worms).—The larvæ are killed by 2—3 per cent. solutions of soft soap.

*Phoeotribus liminaris* (Harris).—Attacks bark of peach-trees in Canada. To overcome it use a soft soap solution to which the consistency of a thick oil has been given by carbonate of soda in strong solution.

*Silpha opaca* (beet carrion beetle).—To overcome this insect use a mixture of equal parts of amyl alcohol and soft soap, diluted to produce 1—2 per cent. solutions of soap, which must be sprayed on the beets.

*Crioceris asparagi* (the asparagus beetle).—The larvæ which live on the surface of the leaves of the asparagus is killed by Nessler's insecticide (formula 7) without injuring the plant. Sprayings, if need be, are repeated in the summer.

*Pieris rapæ*, L. (small white cabbage butterfly); *Pieris brassicæ* (large white cabbage butterfly).—Alvood advises to kill these caterpillars injurious to cabbage by spraying the cabbage with 6 per cent. solutions of soft soap.

*Gastropacha neustria* (the lackey or barred tree lackey moth).—The caterpillars, which shelter at night in a nest of gauze which they spin, are dislodged by soap solutions and killed afterwards by various methods.

*Cochylis ambignella*, Hubn. (cochylis of the vine); *Eudemis botrana* (tortrix of the grape).—Soft soap is an excellent product for destroying the caterpillar of the cochylis. In 1896 a circular of the Italian Minister of Agriculture recommends the use against cochylis of pure soft soap solutions, say mixtures of soft soap and alcohol, or of soft soap and benzene. A 3 per cent. solution suffices (Del Quercio); 2 per cent., according to Passerini. Dufour recommends a soft soap solution, with which a little tobacco juice has been incorporated. In the laboratory this solution, concentrated to 10 per cent., kills all caterpillars, but it is too strong to be used on the vine. On the latter a solution stronger than 4—5 per cent. of soap must not be used. According to Petrobelli treatment with soft soap has, however, a deadly effect on the flowers and the grapes. When the sprayings are abundant a coating forms on the grape, which ends by burning the skin; when there is little liquid a drop accumulates at the lower part of each fruit, which, in concentrating, attacks the skin, which tears at that spot. Petrobelli likewise accuses this insecticide of giving a bad taste to the wine.

*Hyponomeuta malinella*, Zell. (small ermine moth of the apple).—Nessler's insecticide is used to combat the caterpillar of this butterfly hid in its silky nest.

*Gryllotalpa vulgaris*, Latr. (mole cricket).—Corot kills the mole cricket thus: Before tilling the soil it is well raked to render the surface clean and neat; the earth is then beaten, watering it if need be. During the night the mole crickets dig new tunnels, which are seen the next morning. The fresh tunnels are opened with the finger and tepid soapy water poured in from a watering-can.

*Formica* (ants).—Soap is used against ants infesting trees.

*Eriocampa adumbrata*, Kl. (saw-fly of the slug-worm or slimy caterpillar).—Nessler's insecticide (formula 7, p. 331) is an excellent medium to kill the slimy caterpillar.

*Blissus leucopteris*, Say.—This bug, injurious to *Gramineæ*, is destroyed by spraying with soap solutions (Quaintance).

*Diaspis* (*Aulacaspis*) *pentagona* (white peach scale) heavily infested papaw trees, in the Virgin Is., which were cleansed by the use of fish-oil soap at the rate of 1 lb. to 5 U.S. gallons of water.

*Phyllobius oblongus* (Coleoptera injurious to the pear).—Horfer recommends abundant spraying with a 1 per cent. solution of soap.

*Aphidæ* (plant lice).—To destroy green lice in general Ducloux recommends two bouillies: (1) Soft soap 5 lb., tar 15 lb., water 2 gallons; (2) Tobacco extract 2—3 gallons; soft soap 5—10 lb., methyl alcohol 1 gallon, carbonate of soda 5 lb., water 100 gallons.

*Aphis papaveris.*—Killed by a few sprayings with 5 per cent. soap solution (Noel).

*Aphis rosæ*, L. (rose aphis).—Green lice, as well as all unprotected lice, are readily destroyed by pure soap solutions and insecticide mixtures with a soap basis. Not being covered with a protective down like the woolly aphis, and living on the surface of the plant organs from which they draw their nourishment, they are far more accessible to insecticides, and resist them less. The solutions should be diluted so that neither the soap nor the insecticide injure the foliage. Solutions of 2 per cent. of soap produce the desired effect. Lowe considers that 1·5 per cent. of whale oil soap is better than all the other methods, if used as a spray, as soon as the lice appear on the young leaves. As winter treatment to kill the eggs or the adults in their refuge, a 50 per cent. solution of soft soap may be used, according to Taschenberg. Many mixtures are recommended to replace solutions of pure soap; those consisting of quassia and tobacco, and diluted with water so as to contain 1·5—2 per cent. of soap, *vide supra.* Delacroix recommends 1 lb. of carbonate of soda, 2 lb. of soft soap, in 10 gallons of water.

*Schizoneura lanigera*, Hausmann (woolly aphis).—Soft soap is used alone and incorporated with insecticides to kill the woolly aphis because it penetrates the down of white wax which protects the adult and allows the insecticide to act by contact. The U.S.A. Agricultural Department recommends a 6 per cent. solution of soft soap. Muhlberg records the bad result obtained with a 7 per cent. solution of soft soap, whilst Goethe found a 5 per cent. solution very efficient. The season when the soap solutions are used evidently exercises an important influence that explains the different results obtained with the same product, for it is asserted that the young larvæ not coated with down, hatched in November or December, are very sensitive to insecticides, whilst the adults, owing to the agglomerations which they form, often escape the action of the most energetic insecticides. It is thus well to choose the most propitious time for treatment, November and December. At that time they may be successfully destroyed by solutions of 3·3—5 per cent. of whale oil, a dose which has no action on adults. Mixtures of soap and insecticides have a more decided and radical action, but they also must be applied at the time when the delicate larvæ issues from the winter egg. This moment varies with the different plant lice to such an extent that the time of treatment must be varied according to the species which it is desired to exterminate. One of the most energetic insecticides, and also the least injurious to trees, is that recommended by Nessler, consisting of soft soap, ethyl, and amyl alcohol: Dissolve 5 lb. of soft soap in 6½ gallons of rain water, add, after cooling, 2 gallons of ordinary 90 per cent. alcohol and 1 gallon of amyl alcohol. A mixture of 3 lb. of soft soap and 6 lb. of amyl alcohol in 10 gallons of water acts similarly. These insecticides are applied by the brush, such as they are, in winter during the hatching of the eggs, on all the nodosities and cankers produced by this aphis. It is well to prune the tree and to clean the trunk and the large branches before treatment; then the whole tree is sprayed with a solution diluted with an equal part of rain water. Summer treatment with this insecticide is not sufficient to kill the adult. Sorauer recommends a mixture of 50 oz. of soft soap, 2 oz. of carbon disulphide, and 6½ gallons of water. Muhlberg recommends a mixture with tobacco : 3 lb. of tobacco, 5 lb. of amyl alcohol, 2 lb. of ordinary alcohol (formula 9, p. 347). If this last preparation infallibly kills the louse it also injures the buds and the leaves, especially when growing, whilst mixtures of alcohol and soap of equal strength have not this drawback. A wash recommended by the British Ministry of Agriculture for use against woolly aphis consists of : Pyridine 4 oz., soft soap ½ lb., water (soft) 10 gallons.

*Coccides.*—All coccides are exterminated like the *Aspidiotus perniciosus*, Comstock (San José louse). Coccides with a protective shield resist soap solutions, even concentrated, and insecticide mixtures containing soap, better than plant lice. As with the woolly aphis, it is best to attack the larvæ at the moment they are hatched, and when they issue from the protective shell of the dead mother. Pure soap solutions used against the San José louse some days before the fall of the leaf and a little before flowering, in the spring, were found quite satisfactory by Marlatt and Smith. As already seen the former obtained with a 24 per cent. solution more than 97 per cent. of dead coccides. Smith, with whale oil soap of 20—30 per cent., up to 100 per cent. of killed; with 20 per cent. of white soap, strengthened by a little carbonate of potash, 85 per cent. Whale oil soap is the most energetic of all; it is now considered as a specific against coccides. A tepid solution of soap applied on the young larvæ in spring kills them. (He experimented on the coccis of the rose laurel.) A hot solution was used with success by Frank and Kruger. It is necessary to repeat this last treatment until the coccides are exterminated. Unfortunately the soap solution to be effective must be applied of such a strength that it always injures the tree. Winter treatment with 18—30 per cent. of soap always diminishes the blossom; flowering often does not occur at all; the peach is peculiarly sensitive thereto. This drawback may be avoided, according to Alvood, if the treatment be only applied in spring, after the formation of the fruit-buds and at the time of their swelling; they are then not so sensitive to the action of soap. Smith found that a 5 per cent. solution of whale oil soap was quite sufficient to kill the larvæ of all species of coccides, whilst the young and the adults still resist. Ritzema Bos believes that coccides can only be exterminated by destroying the larvæ. With dilute solutions applied even in summer on the trunks, the drawbacks resulting from the use of concentrated solutions are obviated. Solutions of soap and amyl alcohol, those which contain insecticides, are all used for the destruction of coccis; they behave like solutions of pure soap but act in weaker solutions.

*Thrips cerealium* (thrips of grain crops).—Quaintance advises spraying with 0·5 per cent. solution of whale oil soap.

*Tetranchus telarius* (red spider).—Stone, Fernauld, and Waugh recommend a mixture of sulphur and soapy water to destroy this acarus.

Against locusts [*Locusta migratoria*] in the Philippines a solution now generally recommended is soft soap, 1 lb. to 4 gallons of water, this having given satisfactory results during an invasion in 1923. The soap used was a yellow Chinese soap, and it was applied with a bucket spray pump and rubber hose. The kind of soap and concentration are important factors in the efficacy of this method. The insects must be thoroughly covered. If well sprayed, though some individuals may apparently revive, they generally succumb to the action of the soap later.

# CHAPTER XXI

CARBON COMPOUNDS (*continued*)—PRODUCTS OF THE AROMATIC SERIES — BENZOL — PARADICHLORBENZENE — COAL TAR — WOOD TAR — NAPHTHALENE.

**Benzene,** $C_6H_6$.—**Preparation.**—Benzene or benzol is extracted from the tar from the distillation of coal. The products of the distillation are separated by fractional distillation.

**Properties.**—Benzene is a colourless, mobile liquid with a peculiar odour, boiling at 80° C.; its density is 0·880 at 20° C. Benzene is soluble in alcohol and carbon disulphide; it is insoluble in water. It dissolves fats and various resins. Absorbed by man, it produces a rather dangerous drunkenness. As an injection it produces rapid anæsthesia followed by cramp.

**Action on Plants.**—Pure benzene has a corrosive action on plants; a drop placed on a cabbage leaf makes a hole there in a few days. Blazek examined the action of benzene vapours on the living vegetable cell and found an abnormal division of the nucleus, generally into four without membranous separations. Nemec found the same degeneration of the cells of *Vicia fabia* by a 1 per cent. solution of blue vitriol. When cells so modified by the vapour of benzene are placed in a pure atmosphere, the division disappears and the cell becomes normal. The action of benzene would thus appear to be unfavourable to the normal evolution of the plant, but this action is only fleeting and disappears with the cause which produced it. Benzene as a proposed substitute for carbon disulphide has the great advantage over the latter of being less injurious to the plant and its roots. The maximum dose borne by a vine in a 4-litre pot is 20 cubic centimetres, emulsified with 20 cubic centimetres water. Trials on haricots and weeds show that benzene does not kill plants except in comparatively large doses. Beans stand, as a maximum dose, up to 10 cubic centimetres per 2 litres of earth (10 in 2000); weeds only have the edges of their leaves dried when ½ gramme of benzene is incorporated per litre of earth in the soil.

**Action on Insects.**—Benzene kills insects by contact and by its vapours. Mouillefert examined its action on phylloxera and found that dipped in benzene the phylloxera and its eggs were killed in five minutes.

**Use.**—It has been proposed to substitute benzene for carbon disulphide against the larvæ of the lamellicorns, although the experiments of Mouillefert had shown that it was incapable of fulfilling this role against the phylloxera. It has, compared with carbon disulphide, the triple advantage of (1) cheapness; (2) diffusing more slowly in the soil when it is used with the injector; (3) of being much less injurious to the roots of plants. In spite of its properties it does not replace carbon disulphide, except in isolated cases, and it can never render the same services as the latter. Its preponderating advantage over carbon disulphide is that it has a more prolonged action, especially in warm, dry weather. Benzene is also used in emulsions against aerial parasites, either pure or mixed with other insecticides. Debray records the good effect of an emulsion consisting of benzene 2 lb., ordinary alcohol ½ lb., soft soap 3 lb., in 10 gallons of water; and a solution of naphthalene in 8 parts of benzene.,

*Melolontha vulgaris*, L. (cockchafer).—The benzene from gas-works destroys the white-worm. Mohr advised its use as far back as 1893. Ritzema Bos records the good results obtained by treating fields in Holland, Taschenberg those obtained in the neighbourhood of Trieste, and Croisette-Desnoyers in pine plantations. Injections of benzene into the soil are mady by the injector, like those of carbon disulphide. The nature of the soil, as well as the season, decides the number of holes and their depth. Thus holes are made of 8-10 inches intervals in light soil and 6-8 inches in heavy soils; the larvæ of the cockchafer living, according to the season, at different depths, the depth of the holes with the injector must be varied with the position occupied in the soil by the white-worm. The depth varies from 12–28 inches. The precautions to take are described under carbon disulphide. The amount of benzene to use per hole is 5 cubic centimetres. Fields of lupines only receive one injection per square metre. In pine plantations Croisette recommends to make injections every 70 centimetres (say 28 inches), and two to three injections a year. The results obtained in young plantations which suffer much from white-worm are perfect, and the treatment in no way injures the trees. Benzene has often given favourable results where carbon disulphide has failed. These doses sufficient to overcome the lamellicorns never injure the plant.

*Cetonia stictica*.[1]—Ritzema Bos and G. Staes advise to destroy it to inject 5 cubic centimetres into dunghills every 8 inches by the injector. The benzene destroys the larvæ.

*Elaterides* (wire-worms).—Ritzema Bos found that wire-worms, the larvæ of the elaterides, resist benzene injections.

*Otiorhynchus sulcatus* (vine weevil).—Benzine has been recommended by Mohr in sprayings round the stocks with the view of destroying the larvæ of this weevil. Ritzema Bos regards it as inert in this instance.

*Ceutorhynchus sulcicollus* (cabbage weevil).—Mohr advises to combat it with benzene. As soon as the plants have five leaves, holes are made 8 inches around the plant, 8–12 inches in depth, and 5 cubic centimetres of benzene run into them and the holes closed up forthwith.

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[1] CETONIÆ.—Coleoptera, some of which are gilded, 1—2 centimetres in length, the larvæ of which live in dung. The adult insect passes its life on flowers of which it devours the pistil and the stamens. They may become injurious to fruit trees, especially the *Cetonia stictica* and the velvety cetoin, *Cetonia hirtella*, on the vine. *Cetonia aurata*, the green rose-chafer or golden rose beetle, is one of the largest and most destructive beetles.

The adult insect may also be exterminated by spraying with a soapy water emulsion of benzine.

*Molytes coronatus* (carrot weevil).—To destroy larvæ which attack fleshy part of carrot, Mohr makes holes round young carrots 4 inches deep, into which he pours 5 c.c. of benzol and fills up at once.

*Saperda carcharias*, L. (*Saperde chagrinée*).—To destroy the caterpillars in their burrows, chloroform, turps, and benzene are used. Benzene is preferable. De la Blanchère operates thus: By means of a gouge 1 centimetre ($\frac{2}{5}$ inch) in diameter the workman widens and enlarges each hole, which is hidden in the folds of the bark and under the moss of the lichens, but the presence of which is revealed by detritus resembling moist sawdust. He cuts the edges neatly, and quickly introduces into the hole a small hook, by means of which he draws out the detritus which blocks up the entrance to the burrows. The orifice being cleaned and in perfect communication with the burrows, the workman introduces, by means of a small needle, taking care not to press them, two or three plugs of cotton previously steeped in benzene. He forthwith closes the hole by means of a plug of rather stiff Roman cement, which he applies with a small trowel in such a way as only to penetrate into the hole to a small depth and to cover the edges with several centimetres of cement. The latter hardens rapidly and the hole is hermetically closed. The benzene in volatilizing fills the burrows with its vapours and asphyxiates all the creatures living therein. When the button which forms round the wound has repulsed the cement, the odour still suffices to keep off insects until the wood recloses of its own accord. An inspection every fortnight after applying this process assures the destruction of all the generation of the preceding year. The trees so freed do not suffer from the treatment, heal rapidly, and regain their vigour.

*Cossus ligniperda*, L. (the goat moth).—The process described for exterminating the larvæ of the Saperdas may be successfully used for that of the Cossus. To prevent the females from laying their eggs on the trunk, Truelle advises to coat it with a concentrated solution of green vitriol, or with a mixture of cow-dung and clay.

*Zeuzera æsculi*[1] (the wood leopard moth, horse chestnut Zeuzera); *Trochylium apiformi*,[2] L.—The caterpillars of these two butterflies are combated like the larvæ of the Saperdas.

*Agrotis segetum* (the common dart moth).—According to Ritzema Bos, the grey-worm is exterminated by benzene in the same way as the white-worm and with full success. The caterpillars of an allied species, *Agrotis valligera*, very injurious to pine-trees, are exterminated in the same way.

*Cochylis ambignella*, Hubn. (cochylis of the vine); *Eudemis botrana*,

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[1] ZEUZERA ÆSCULI (wood leopard moth).—The caterpillar of this bombyx has analogous habits to those of the *Cossus ligniperda* (*q.v.*); it attacks chestnut-trees, elms, limes, birches, oaks, apple-trees, pear-trees, and others; its life as a caterpillar also lasts three years.

[2] TROCHYLIUM APIFORMI (*Sesia apiformis*).—Butterfly resembling a wasp. It shows itself in June. The female lays its eggs at the base of white-wood trees (poplar, birch, willow, aspen). The caterpillars bore holes, which may traverse the tree from one part to another, and even reach the roots.

Schiff. (eudemis or tortrix of the vine).—The Italian Ministry of Agriculture recommends an emulsion of soft soap 3 per cent., alcohol 0·5 per cent., benzene 1·5—2 per cent. Debray obtained good results with this emulsion.

*Lopus sulcatus* (Grisette de la Vigne, Margotte).—Benzene emulsions are used as sprays, according to Pratigeon, for the destruction of the larvæ of this bug at the time when they are still on the charlock and groundsel at the foot of the stems. The adults are thus prevented from getting on the vines.

*Tipula oleracea* (crane-fly, known as daddy longlegs).—The larvæ, injurious as much to the roots of strawberries as to salads and spinach, may be destroyed by shallow injections of benzene into the soil. It suffices that the injections be 1 centimetre from the plant, that they do not hurt it.

*Tingis pyri* (tiger beetle of the pear-tree).—According to Taschenberg and Caruso an emulsion of 1 per cent. benzene and 1 per cent. soft soap is the best way to destroy the tiger beetle and the least injurious to the pear-tree.

*Pulvinaria vitis*, *Coccus vitis* (vine scale, vine cochineal), Targioni-Tozzetti (phylloxera of the vine).—Benzene destroys all the phylloxera on the roots of the vine in pot, but has proved itself inefficient on the large scale according to Mouillefert. A stock stripped received ½ litre of benzene emulsified in 10 litres of water; the greater part of the phylloxera were destroyed it is true, but the roots at a great depth still bore numerous living lice. Benzene cannot therefore, it would appear, replace carbon disulphide.

**Paradichlorbenzene,** $C_6H_4Cl_2$.—Obtained by chlorinating monochlorobenzene.

The value of paradichlorbenzene for the control of *Lepidoderma albohirtum*, Waterh. (grey-back cane-beetle) in the sugar-cane plantations of Queensland has now been definitely established. Recent experiments are described in which the material in doses varying from $\frac{1}{16}$ to ¼ oz. was buried at an average depth of 4½ inches. The rows were from 12 to 18 inches apart and about 6 inches from the centre of the stools. Fumigation does not in any way affect the normal development of the stools; in treated plots the sugar-cane appeared to be slightly higher than in the untreated areas, the difference in tonnage being quite appreciable. There is reason to believe that paradichlorbenzene, like carbon disulphide, may stimulate the growth of cane by destroying certain injurious soil bacteria.

*Capnodis tenebrionis*.—Paradichlorbenzene has been successfully used against this Buprestid in Algeria.

*Termites* have been particularly injurious in some districts of Queensland; soil fumigation with paradichlorbenzene to protect the newly planted cane seems likely to yield good results. In the laboratory, workers, nymphs and soldiers of *Termes meridionalis* proved more susceptible to the fumigant than larvæ and soldiers of *Mastotermes Darwiniensis*. *Scolytus rugulosus*, Ratz. (shot-hole borer) has become more abundant in peach trees in the U.S.A. and may be controlled in a limited way on old trees by the application of paradichlorbenzene dissolved in pine-tar creosote and made into an emulsion with caustic soda, diluted at the rate of 1 to 5. This mixture has also been used successfully against a pine bark beetle.

*Clothes moth.*—A new protection against clothes moths has been found by the U.S. Bureau of Entomology in the form of paradichlorbenzene. It has been established that napthhalene and paradichlorbenzene are among the most dependable substances that can be used in tight containers for protection against all stages of the clothes moth.

*Scutigerella immaculata.*—Paradichlorbenzene and calcium cyanide as soil fumigants have given encouraging results in controlling garden centipedes and other soil pests in California. Paradichlorbenzene was efficient at the rate of one ounce to three linear feet when scattered along both sides of the asparagus row, the furrows being made close to the crowns with a garden hoe.

**Tar.**—Tar is the liquid product which results from the dry distillation of coal and numerous organic bodies. Its nature varies with the raw material which gave it birth, but it is always oily, viscous, of a dark colour, and empyreumatic odour. Tar is insoluble in water.

1. *Coal Tar.*—Coal tar is a by-product of gas manufacture. It consists of a mixture of some fifty organic compounds, amongst which are benzene, toluene, naphthalene, and phenols. It is a black viscous liquid.

2. *Wood Tar.* –Wood tar is obtained by the dry distillation of wood. It is a by-product in the manufacture of pyroligneous acid and wood charcoal, also in the distillation of pines after the extraction of the turpentine. When it is desired to obtain tar chiefly, the distillation is slackened and 18 per cent. of tar may be obtained in that way. The nature of the tar varies with the nature of the wood and the method of extraction used. Tar obtained by carbonizing wood has neither the same composition nor the same appearance as that obtained by distillation. The first is black and approaches coal tar; it contains a large amount of naphthalene. The second is pale, almost viscous, and contains paraffin. The composition of wood tar is thus more complex than that of coal tar. It contains benzene, toluene, styrolene, naphthalene, phenols, guaiacols, creosote, and other aromatic compounds. Tar is used in human therapeutics as an antiparasitic agent.

**Action of Tar on Plants.**—Tar is a substance comparatively harmless to the tree. Used such as it is on restricted surfaces of the bark of a tree—for example, as a circular ring to prevent the access of insects or to cover wounds—it is without action on the growth and does not injure the tree.[1] Tar does not kill the cells which it penetrates, but it preserves them from decomposition so that neighbouring cells may grow and develop normally. The cellular layer which is penetrated by the tar only neasures 1—2 millimetres in summer. It is therefore better to apply tar to wounds in winter. It has been found that tar, after remaining seventy days on the tree had not been entrained by the sap, and had not penetrated further than at the time of application. However, Sorauer and Von Tuboeuf remarked that tar must not be abused on fresh wounds or on young trees, for in their opinion it is only old wounds and old trees which stand tar with impunity. Robert found, however, that far from injuring the trees, the layer of tar, if it be not too thick, may act as a tonic to the wound and favour cicatrization and thus enable it to cover itself with fresh bark. Boiteau observed on stocks treated with tar rather grave disorders at the beginning of growth: a delay in the latter and chlorotic vine leaves which disappear later on. Sajo has observed that tar, especially wood tar, is injurious to dormant eyes. According to Berlèse and Fleischer, solutions of tar in alkali diluted with water are injurious to the leaves above 5 per cent. Sprayings should never be done during flowering nor before the fruit has formed.

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[1] *Translator's Note.*—This is no doubt true as regards old trees, but tar should not be applied to young trees with tender bark.

**Action on Insects.**—Tar is insecticidal by contact, but its action is not intense, and it requires strong doses to kill insects. In strong doses it kills the eggs of butterflies; in solution in caustic alkalies containing 2—4 per cent. of tar it kills insects with soft skins, such as lice and caterpillars; from 1—5 per cent. it kills *Orthoptera*, *Hymenoptera*, *Lepidoptera*, and *Diptera*. The larvæ of the saw-flies are killed by 5 per cent. emulsions.

**Use.**—Bituminous shale was used by the Greeks to keep off insects. In our days tar is used as it is to destroy the mass of butterfly eggs, and to form around the trunk an impassable barrier, and a trap to apterous insects and their larvæ, which are obliged either to descend the tree to continue their metamorphosis in the soil or to ascend the tree along the trunk after their transformation into a perfect insect. The bouillies obtained by mixing tar, more especially wood tar, with caustic alkali, alkaline carbonates, or with soft soaps, are used in spraying insects with a soft skin. A useful preparation, sold under the name of "Rubinia," is prepared by boiling 50 parts of wood tar with 50 parts of caustic soda, 30° Bé. This preparation is soluble in distilled water with a red coloration; it should be diluted with rain water. Tar bouillies are also made containing blue vitriol, naphthalene, and lime. Howard recommends a bouillie of blue vitriol and tar, obtained by stirring energetically 6½ lb. of coal tar with 5 gallons of boiling water into which there is poured when the emulsion is complete, and after removing the blackish froth, a solution of 12 lb. of blue vitriol in 5 gallons of water. Tetard recommends an emulsion with petroleum and carbolic acid made thus: Heat 6 gallons of tar; remove from the fire and add while stirring 3 litres of petrloeum and 10 litres of carbolic acid. Balbiani recommends a mixture of coal tar, naphthalene, and lime prepared thus: Dissolve 3 lb. of naphthalene in 2 lb. of coal tar, and pour the mixture into 100 lb. of lime slaked with a little water. After intimately mixing these substances they are gradually thinned by adding 40 gallons of water. Rathay recommends an analogous bouillie containing 4 lb. of coal tar, 12 lb. of naphthalene, and 24 lb. of lime in 6 gallons. "Pitteliene" used in Italy is a mixture of oil and tar.

**Use to Destroy Weeds.**—One of the most efficient methods to free paths and roads from weeds consists in watering them with an emulsion of equal parts of water and tar. The weeds do not grow again for two years. But it has the disadvantage of being as dear as hoeing and of browning for some time the spots treated. However, it is expeditious and kills earth-worms at the same time.

**Use against Fungi.**—*Sphærotheca pannosa*, Wallr. (mildew of the rose).—Del Quercia and Baroni found that rose mildew was destroyed by coal-tar bouillies. They advise for this purpose to spray before flowering with a bouillie consisting of 1½ lb. of carbonate of soda and ½ lb. of coal tar in 10 gallons of water. The bouillie injures the colour of the roses because it is alkaline. Martini prefers a bouillie consisting of wood tar dissolved in soda lye 1½ lb., blue vitriol 1 lb., quicklime 1 lb., in 10 gallons of water.

*Ananas* (cane-sugar disease).—This fungus is propagated chiefly by the cuttings. By coating the sections with carbolized tar, Went overcame this disease, preventively, better than by cupric bouillie.

*Nectria ditissima*, Tul. (canker of the pear-tree and apple-tree).—The cankers of fruit trees, whether caused by the woolly aphis or by the nectria fungus, are overcome and cured when the tree is not too much infested by completely excising them, and covering the wounds by a mixture of wood tar and pulverized wood charcoal, or by a mixture of 1 part of coal tar and 4 parts of pulverized slate, or even by a thin layer of hot tar. The tar prevents contact with the air, kills the germs of cryptogamic disease, and stimulates the growth of the cells of the epidermis so that cicatrization is accelerated and large decorticated surfaces become covered with healthy bark in the course of the year.

*Rot of Cuttings.*—It has been found that tarring the ends of cuttings prevents their rotting in the soil. This effect is especially noticeable when Bordeaux bouillie is combined with the tar by dipping the end to be buried first into the bouillie and then into the tar.

*Polyporus igniarius*, Fries (false tinder).—To prevent its ravages care must be taken to cover with a layer of tepid tar all the wounds produced on trees by lopping, hail, the sun, woolly aphis. If the hoods of the polyporus show on a branch, this spot must be deeply excised to destroy the greater part of the mycelium, and the whole covered with tar. Hollow trees may be filled with sawdust impregnated with wood tar, and the openings plugged with clay or mastic. That prevents the internal decomposition from pursuing its course, for the fungus must have contact with air for its development.

**Slugs.**—The ring of coal tar, ⅓—⅔ inch wide, is quite sufficient to prevent snails and slugs from crawling along the trunks of trees and to avoid their ravages.

**Use on Insects.**—*Melolontha vulgaris*, L. (cockchafer).—Razeburg remarked that the cockchafer had a great repulsion for tar. He recommended to protect plants against their attacks to bury in the hole, dug for planting, a rag steeped in tar. Weny found that Balbiani's mixture, consisting of tar, naphthalene, and lime, eradicates the white-worm of the vine, and Landisch points out that it suffices to insert, at certain intervals, and at a depth of 10 inches, pegs dipped in tar to protect a crop threatened by the white-worm.

A 3 per cent. solution of a preparation of tar distillates, used at the rate of about 35 fl. oz. for a young tree and 52—70 for an old one, is said by a German authority to free cacao roots from Melolonthid larvæ without any ill effect on the trees having been observed, though further investigation is needed to ascertain if the soil-bacteria are destroyed.

*Pseudococcus vitis*, Nied.—In June and July spraying with a petroleum-soap emulsion should be carried out in order to destroy the coccid, when the sooty fungus produced by it will also disappear. In winter the old bark should be cleared from the stocks, which may then be brushed with a mixture of heavy tar-oil 5 parts, sodium carbonate 2, and water 95. Winter treatment is of greater importance than summer spraying.

*The destruction of house flies in the maggot stage.*—Residual coal tar, that is to say, oil freed from naphthalene and phenol, in 2½ per cent. water emulsion, with the addition of resinate of soda, forms a stable emulsion that allows of a thin but sufficiently efficacious layer of oil being spread over very large surfaces of decomposing matter. The special odour of this oil drives away all brachycerous diptera, and its deodorising property is such that the unpleasant smells generated by putrefying substances can be lessened to a very great extent. The emulsion can be applied by means of sprayers similar to those used in agriculture, or better, by machines working by the pressure of liquid carbonic acid.

*Euphalerus citri.*—In spraying operations against this Psyllid, 28 c.c. creosote, with 4 oz. soap in 11,200 c.c. water, killed 90 per cent. of the insects in the Punjab.

*Wood-borers.*—Creosote is the most efficient liquid that has yet been found for the protection of wood against boring insects in Australia. For external work, or where discoloration does not matter, it is always recommended, the vapour alone being sufficient to kill both grubs and beetles. The creosote should be applied liberally with a brush or as a spray. Where it is desirable to avoid staining, a mixture of creosote and kerosene may be used; 1 part of creosote to 8 of kerosene leaves no stain if the creosote is not too dark. Orthodichlorobenzene, either alone or as a solution of 5 per cent. or 10 per cent. in kerosene, kills the borers after one hour's exposure, and is particularly suitable for household furniture. Paradichlorobenzene is somewhat cheaper and, both in solution in kerosene and in crystalline form, has proved an effective deterrent for the treatment of timber in museum show cases.

*Apple aphis.*—Several tar distillate washes have formed the subject of trials at Long Ashton, to ascertain their comparative power for killing eggs of the permanent apple aphis. Not all had the same capacity for killing, and it will be necessary for some makers of these proprietary washes to adjust their recipes to secure a more efficient mixture. The majority of the washes tried when made up to form a 10 per cent. emulsion with water gave over a 99 per cent. kill, which is quite satisfactory. With a 5 per cent. solution the kill was still good, but less complete, and it appears probable that for general spraying an intermediate strength would prove suitable. Emulsions of 2½ per cent. lower were less effective and left too many eggs uninjured to hatch out in the spring to be commended. One of these sprays was useless at all strengths. These tar distillate sprays, when properly prepared and applied in December or February at suitable strengths, have a great egg-killing capacity, and their increased use in the fruit orchards in the future will prove advantageous to the grower and permit of the production of cleaner and better crops.

*Valgus hemipterus.*—A small *sitoma*, the larvæ of which rapidly destroy the props and posts of enclosures, by nibbling the underground part even when tarred. To preserve them, they must be treated thus: The props and posts are coated in the underground portion with a thick layer of white lead ground in oil. Powdered sandstone is dusted over this layer, and allowed to dry completely. A coat of tar is then given and the props inserted. The wood is thus unattackable, and is preserved for a long time.

*Bruchus pisi* (pea weevil).—Fleischer recommends to spread the peas on a sieve and to distribute thereon an emulsion of 1 pint of tar in 2½ gallons of water, and to stir the peas well.

*Otiorhynchus populeti* (weevil injurious to the vine).—Balbiani's mixture is recommended by Sajo to eradicate this weevil.

*Scolytus rugulosus*, Koch.—Scolytus very injurious to apple-trees. Bauer recommends to cover with tar the parts of the trunk infested.

*Anoxia villosa.*—The larvæ of this insect are injurious to the *Magnolia grandiflora.* Camerlings obtains good results by excavating a pit around these trees 32 inches wide by 10 inches deep, and watering these pits with 30 litres (6·6 gallons) of an emulsion of 3 per cent. of "Pitteleine" (p. 358). The pits are filled with earth in twenty days.

*Galeruca calmariensis* (galeruca of the elm.)—The most simple way to destroy these larvæ is to seize the moment, at the end of July or beginning of August, when the adult larvæ descend along the trunk to be converted into a grub in the soil. At this time a ring 4—8 inches wide is painted round the trunk near the bottom. The larvæ which descend remain glued to this layer of tar. To destroy those which have let themselves fall, and which are buried in the ground, the soil round the tree is watered with gas liquor from the gas-works. Kunckel recommends a bouillie made by making 5 lb. of tar and 1 lb. of soft soap into a paste, and thinning this preparation with 9·4 gallons of water. This bouillie is used to spread on the leaves.

*Haltica oleracea* (the garden altise, the altise of cruciferous plants). —These altises entirely nibble the seedling turnips, cabbages, and rapes, and other cruciferous seedlings, especially during hot and dry periods when the fields are despoiled of their crops. At that time a very efficacious method consists in spreading dry wood sawdust steeped in tar. The earth fleas are driven off by the smell of the tar; 2 lb. of tar per 100 lb. of sawdust are used.

*Blissus leucopterus*, chinch bugs, are very injurious to maize, and every effort should be made to stop their progress before maize is reached. The most successful barrier under U.S. conditions proved to be a barrier made by dragging a weighted plank, 10 to 12 inches wide, across the line of advance, thus forming a smooth path on which to lay tar. If the insects have reached the maize, the path should be laid a few rows ahead of the line of infestation. In the centre of the path, a series of post-holes, with bevelled edges, 12 inches deep and 20 to 30 feet apart, are dug. Tar should be laid about an inch wide on the side of the path furthest from the migrating insects, so that it touches the rim of each hole. They will not cross the tar, but will travel parallel to it until they fall into the holes. In each hole should be placed about 2 inches of hydrated lime, which should also be dusted round the sides about half way up. The insects are soon suffocated in this. The holes should be visited once daily to stir the lime, which should be renewed every 3 or 4 days.

*Locusta* (locusts).—To destroy these on the large scale a 5—10 per cent. solution of Rubinia is used.

*Pieris brassicæ* (white cabbage butterfly).—The grubs are killed by a 2 per cent. solution of Rubinia.

*Ocneria dispar*, L. (bombyx dispar, gipsy moth, zig-zag); *Cnethocampa processionea*[1] (processionary bombyx of the oak).—The eggs of these bombyces are killed by tar; a layer of tar is spread on the agglomerations of the eggs. Debray advises to use a mixture of 4 gallons of tar and 1 gallon of petroleum. Jacobi found the tar more effective than the petroleum. To kill the caterpillars in their nests Sonnino sprays with a 5 per cent. solution. Pissot recommends to drench the nests with a mixture of 10 parts of tar and 100 parts of water. Berlèse finds it better to use an emulsion of 2 per cent. of "Pitteleine."

*Bombyx pini* (the pine-tree lappet moth).—Ratzeburg advises, so as to glue them on their passage along the trunk, to draw a ring on the bark at the right times, 52 inches from the ground and $6\frac{1}{2}$—$9\frac{1}{2}$ inches in diameter. The scales of bark are removed from this spot, and it is then coated with tar. A little grease is often added, or birdlime made by heating linseed oil. The caterpillars which touch the tar die in a few days.

*Cheimatobia brumata*, L. (the winter moth).—De la Blanchère finds the best way to overcome this moth is to prevent the female from climbing along the trunk of the trees to lay its eggs. With this end in view the trunk is scraped a little above the surface of the soil, and this ring is coated with tar or with a mixture of equal parts of tar and fish oil. To protect young trees sensitive to tar a band of paper or cardboard is fixed around the trunk and coated with this sticky substance. The paper must fit well round the trunk. These rings should be made from the end of September to the end of December, and renewed from time to time if necessary—every three days if made with pure tar; at greater intervals if they consist of different sticky substances. Unfortunately, these last preparations are less harmless than tar to the health of the tree. Leroux advises to shake the tree by sharp blows, which causes the females to fall. These to reascend the tree encounter the obstacle of a fresh layer of tar. The females hatched prematurely are thus reached. C. de Labonfon advises from 20 October to 20 November to surround the trunks of apple-trees and pear-trees, about 3 feet from the ground, with a piece of course stuff held by a hook and steeped in coal tar. The eggs deposited below the ring by the females, pressed to lay, are destroyed by scraping or by liming.

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[1] CNETHOCAMPA PROCESSIONEA (*Bombyx processionea*).—Moth of 3 centimetres, greyish, uniform with dark sinuous bands on the wings; it flies in August and September, lays its eggs in packets of 200 on the bark of oaks and covers them with hair; the eggs pass the winter.

*Grapholitha Woeberiana* (tinea of stone fruit).—To overcome this tinea, the trunk is scraped and a slight layer of tar applied. If the operation be done in season it will prevent the female from laying its eggs on the trunk.

*Hyponomeuta malinella* (small ermine moth of apple-tree).—To destroy these caterpillars Taschenberg advises a 5 per cent. emulsion.

*Cochylis ambignella*, Hubn. (cochylis of the vine).—Opinions are much divided as to the action of Rubinia on caterpillars of the cochylis. Fracasso, Legrenzi, Farini, and Silva found 4 per cent. doses of Rubinia inactive, whilst Berlèse, Martini, and Peglion find it energetic at the same strength. The latter does not injure the vine. Peglion recommends to use these solutions before flowering or after the grape is formed, so as to prevent the injurious action of the product during flowering. Mixtures of sulphur, Bordeaux bouillie and Rubinia are used in Italy to combat simultaneously cryptogamic diseases and the cochylis. These preparations destroy the eggs. Martini found that eggs of the cochylis laid on paper steeped in Rubinia never hatched. He advises to use the following mixture: Rubinia 1½ lb., blue vitriol 1 lb., quicklime 1 lb., in 10 gallons of water. Berlèse and Leonardi recommend spraying the buds as soon as they shoot out with a bouillie consisting of 5 lb. of Rubinia, 5 lb. of blue vitriol, 5 lb. of lime, in 10 gallons of water. After flowering the sprayings are continued and repeated to the beginning of July with a bouillie of Rubinia 1½ lb., blue vitriol 1 lb., lime 1 lb., in 10 gallons of water. A diminution of 62—63 per cent. of cochylis is obtained in that way. Battaglini recommends preventive treatment either with 1 per cent. Rubinia or with a mixture of 2 per cent. Rubinia with sulphur. Spraying should be begun on 28 April. The number of eggs diminishes by the first treatment. The eggs disappear after the second, which should take place on 15 May; the third treatment is given on 27 June, and the fourth on 4 July.

*Tortrix vitana* (pyralis of the vine).—G. Basile proposes to coat the vine after pruning with a mixture of 6 lb. of tar in 10 gallons of purin. Scalding, however, gives better results.

*Hylotoma rosæ*[1] (rose saw-fly).—To destroy, spray with 2 per cent. Rubinia, in fine weather, preferably at noon.

*Eurydema ornatum*.—To destroy, water the cabbage leaves with tar-charged water.

*Schizoneura lanigera*, Hausm (woolly aphis).—To destroy this aphis Del Quercio, after pruning the trees and cleaning the nodosities, coats the wounds with an emulsion of tar 3 lb., soft soap 5 lb., water 9·6 gallons. In summer an emulsion is used of carbonate of soda 5 lb., wood tar 5 lb., water 10 gallons. Muhlberg found that rectified Russian tar, practically colourless, is an excellent medium to induce the cicatrization of wounds formed by the woolly aphis. A tree treated by an emulsion of soft soap and amyl alcohol, Nessler's formula, and the wounds of which have been afterwards tarred, may be regarded as cured. Tiele ranks tar amongst the insecticides whose action is undeniable and decisive.

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[1] HYLOTOMA ROSÆ.—Rose saw-fly of 8 millimetres; black with red abdomen. The green larvæ gnaw the leaves of the rose-trees, only leaving the veins.

**Green lice.**—Berlèse used with success a solution of Rubinia, 1—5 per cent., against green lice; according to Fleischer, it is only with 5 per cent. that a deadly action makes itself felt, but at this strength it is dangerous to the plant.

*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—Mouillefert showed that tar vapours have little insecticide action on the phylloxera. Used in holes dug round a phylloxera-infected stock, tar had no action. However, by increasing the dose and getting nearer the roots so that the tar could act directly and completely drench the soil, it was found to have an appreciable though incomplete effect. Tar may be used to destroy the winter egg deposited by this louse on the aerial parts of the plant. Balbiani recommends for this purpose his mixture of tar, naphthalene, and lime, used as a coating.

*Coccides* (cochineals, kermes).—Tar is used sometimes such as it is to destroy coccides. A thin layer of tar bouillie is spread with a brush on all the trunks. Sajo found that it was tar, especially rich in anthracene, which had a specific action on kermes, chiefly the *Mytilaspis pomorum*, Bouché. This tar is, however, more injurious to the apple than ordinary coal tar. Del Quercio recommends a soapy bouillie consisting of tar 10 lb., soft soap 2 lb., water 8·8 gallons. It is used in winter spraying. After flowering, and during summer, an emulsion must be used of soft soap 30 lb., tar 10 lb., petroleum 2 gallons, in 100 gallons of water, and prepared by mixing 20 lb. of soft soap and 10 lb. of tar on the one hand, and emulsifying, on the other hand, 2 gallons of petroleum and 10 lb. of soft soap in 97 gallons of water, and in mixing the two solutions. This latter treatment is recommended against *Mytilaspis fulva*, *Aspidiotus limonis*, *Lecanium hesperidum*, *Lecanium citri*, *Dactylopius citri*. Rubinia is much used to combat coccides. Berlèse recommends 5 per cent., especially against *Dactylopius vitis* (coccus of the vine), and Marchal against kermes of the orange-tree. Girardi recommends the use of a 1 per cent. solution at the moment when the young larvæ quit the protective shell of their mother and circulate round the tree in search of a place on which to fix themselves. The tar and oil emulsions known as "Pitteleine" are recommended by Berlèse of 2 per cent. strength against *Lecanium*, and by Marchal against kermes of the orange-tree. Del Quercio recommends for the treatment of winter fruit trees, an emulsion of tar 1 gallon, carbonate of soda 5 lb., and water 9 gallons. The carbonate of soda is dissolved in the water and the tar added afterwards whilst stirring.

A 10 per cent. solution of tar kills anthonomes in five minutes. It must be used for this purpose in October and November. The females of *Mytilaspis pomorum* and *Diaspis ostreaformis* are killed at the same time as their eggs. It would appear also that the branches which have been repeatedly sprayed therewith are no longer sought after by these coccides. A 4 per cent. emulsion destroys mosses and lichens. To destroy coccides, Mottareale indicates on the one hand, an emulsion consisting of tar oil 10 lb., soap 10 lb., water 100 gallons, and on the other hand, alcoholic solutions consisting of tar oil 5 lb., alcohol 5 lb., water 99 gallons.

*Tetranychus telarius* (red spider).—Rathay recommends to bark the stock in autumn and to coat it with his mixture of tar, naphthalene, and lime, for in the end of October these acari take refuge under the bark of the stem. The barks should be burned. Berlèse recommends spraying the plant in full growth with 2 per cent. solutions of Rubinia.

*Tar oil emulsions*, now generally used as dormant sprays against insect eggs, had their origin in "carbolineum," a timber preservative, which was based on products obtained in the distillation of coal tar and was insoluble in water. By a process of either chemical or physical emulsification, the active ingredients are converted into a form that, on dilution with water, produces a milky-white emulsion suitable for tree sprays. It is essential that on dilution with water no separation of an oily film shall take place, as this would probably injure the cambium layers. The oils used in the manufacture of most of the brands now offered are of the creosote type, boiling somewhere between 170° and 300° C. (370° and 636° F.). It has not yet been determined which particular fractions of the coal tar distillates possess the highest egg-killing properties. Laboratory experiments have shown that emulsified cresylic acid, containing 50 per cent. of the active ingredient, used at 5 per cent. dilution is as effective in destroying eggs of the silk-worm moth (*Bombyx mori*) as an ordinary creosote emulsion containing 50 per cent. active ingredient used at the same dilution. In order to avoid damage to buds and fruit spurs, it is best to use winter sprays of this type during the mid-dormant period, that is, during January, though instances have been recorded where no damage has occurred when they have been applied as late as March. The tar oil emulsions appear to be effective in destroying the eggs of certain species of Aphids and of *Psylla mali* (apple sucker), but no success has been recorded as yet against Capsid eggs. Where fungus diseases have been prevalent, it is considered preferable, in the present state of knowledge, to supersede tar oil emulsions by lime-sulphur, or at any rate supplement them with a late dormant spraying with the latter.

**Rabbits and Mice**.—Brecher recommends as an infallible method to prevent rabbits and mice from attacking the bark of poplars, to coat the trunk up to 12 inches above the soil with a thin layer of wood tar. Trantwein agrees.

**Birds.**—To protect seed-corn against the voracity of birds it suffices, according to Howard, to moisten it with a bouillie of the following composition: Blue vitriol 12 lb., tar 6½ lb., in 10 gallons of water. The grain is moistened with this bouillie, then dusted with slaked lime to dry it. The following bouillie, recommended by Tetard, is used for the same purpose: Heat 6 gallons of tar, take off the fire, and mix with it whilst stirring 3 gallons of petroleum and 10 gallons of carbolic acid. Crows have a decided antipathy to this odour. One gallon suffices for 1000 lb. of seed.

**Naphthalene,** $C_{10}H_8$.—**Preparation.**—By collecting in the fractional distillation of coal tar the heavy oils which pass between 180° and 260° C. These are let stand for some time in a cold place: crystals of naphthalene are deposited which are turbined to separate the oils containing the phenols and the foreign hydrocarbons. These naphthalene crystals are passed to the hydraulic press, and afterwards washed with caustic soda and sulphuric acid, then with hot water. The rectification is finished by distillation in cast-iron retorts; the naphthalene distils between 210° and 220° C. It is collected in conical wooden vessels slightly moist, in which it solidifies in a few hours. By reversing the moulds, cakes of pure naphthalene are obtained. For agricultural purposes crude naphthalene may be used. It is rarely used alone. It is mixed with such substances as plaster, lime, wood ashes, or sawdust, is drenched with fused or dissolved naphthalene. A great use is made of a mixture of tar, naphthalene, and lime, brought out by Balbiani, and named after the inventor, Balbiani's ointment. It is prepared thus : Slake 120 lb. fat quicklime in lumps by pouring on to it a small quantity of water from a watering-can. The heat disengaged by the hydration of the lime is used to melt 20 lb. of coal tar, and 60 lb. of crude naphthalene, which is run into the lime whilst it is still steaming. The whole is kneaded by an iron stirrer. Whilst continuing to stir the mixture a little water is added so as to sustain the heat of the lime and to keep the mixture pasty. When the lime is slaked no more water is added, the ointment is finished when the paste is homogeneous. Solutions of naphthalene in benzene and alcohol are also used at the rate of 1 part of naphthalene for 8 parts of solvent (say 1 lb. to a gallon).

**Properties.**—Pure naphthalene forms white scales with a strong odour and a bitter aromatic taste. Insoluble in cold water, very slightly soluble in boiling water, naphthalene is soluble in alcohol and benzene.

**Action on Plants.**—Naphthalene does not appear to injure plants; benzene solutions, according to Debray, have no injurious action on the leaves. Mohr's opinion is, however, that this solution injures the parenchyma of plants. The germinative capacity of seed which has been even in prolonged contact with naphthalene is not diminished.

TABLE LXXIII.—*Showing Action of Naphthalene on Germinative Capacity of Cotton Seed.*

| | Percentage of seed germinated. | |
|---|---|---|
| | Seed covered with cotton. | Seed without cotton. |
| Untreated . . . . . . | 86 | 91 |
| Treated with naphthalene, 8 days . . | 87 | 91 |
| ,, ,, ,, 14 ,, . . | 91 | 90 |
| ,, ,, ,, 3 ,, . . | 87 | 88 |

**Action on Insects.**—The experiments of Dufour have shown that naphthalene, so to speak, has no action on caterpillars; however, its smell is so disagreeable to insects in general that this substance drives them off and eradicates them at the time of laying their eggs. The vapours of naphthalene stupefy insects, but they recover in the fresh air.

**Use.**—Naphthalene enters into the composition of many anti-cryptogamic preparations, such as nicotined precipitated sulphur, to which they impart the special properties of removing insects whilst overcoming cryptogamic diseases.

*Silpha opaca*, L. (beet carrion beetle).—Dust the young plants with naphthalene to protect them against that insect.

*Melolontha vulgaris* (cockchafer).—To get rid of the white-worm, De la Blanchère advises to water the soil with water which has been kept over naphthalene. Marsaux advises to bury per acre with the plough 2 cwt. of naphthalene mixed with an equal weight of sand. Finot advises in the culture of strawberries to spread three handfuls of naphthalene per 10 square metres or to dust the dung with it before ploughing it in. Audoin recommends the preventive use of naphthalene to drive off the female cockchafers in quest of a light soil in which to lay their eggs, to sow per acre in April of the cockchafer years 352 lb. of naphthalene per acre, mixed with three times its weight of sand. This method drives off at the same time the females of *Vesperus Xatarti* in vineyards.

*Agriotes lineatus* (striped wire-worm).—When the soil is infested with the wire-worm larvæ of this insect they are got rid of, according to Targiono-Tozzetti, by naphthalene buried in the soil. The action of naphthalene does not last long, and the operation must be frequently renewed.

*Helops lanipes*, injurious to the same extent as *Opatrum sabulosum*.[1] Chapot records excellent results, obtained in driving off these insects, by the use of 15—20 grammes (say $\frac{1}{2}$—$\frac{3}{4}$ oz.) per stock, mixed with the soil around the latter.

*Colaspidemum atrum*, Ol. (Negril).—Crouzel recommends to spread by hand, after the last colds of winter, and before the lucerne shoots up, a finely pulverized mixture of 20 parts of naphthalene and 80 parts of plaster or very dry ashes. A fresh application is given immediately after the first crop is cut so that only the roots of the plant and the soil are impregnated. The smell and taste of naphthalene are thus not imparted to the fodder.

*Otiorhynchus hirticornis*.—Taschenberg reports that coating the vine with Balbiani's ointment prevented it being visited by this insect.

*Atomaria linearis*, Steph.—To drive off these destroyers of young beets Mohr advises to spread on the soil, by means of a bellows, a mixture of 10—15 per cent. naphthalene and 85—90 per cent of lime in powder passed through a sieve.

*Calandria granaria* (wheat weevil).—To remove weevils from wheat seed it suffices to mix it with a little naphthalene.

*Crioceris asparagi*, L. (asparagus beetle).—A mixture of 15 per cent. naphthalene and 85 per cent. of lime in powder kills the larvæ and keeps off laying females.

*Halticineæ* (altises, earth-lice, plant-lice).—Thiel and Reichenbach have shown that naphthalene does not kill altises, but stupefies them and drives them away from a crop; moreover, it is much used for that purpose. Mohr advises a mixture of 15 parts of naphthalene and 85 parts of lime spread on the fields when the young plants shoot up.

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[1] OPATRUM SABULOSUM.—This insect of the family of *Tenebrionides* appears in May. It attacks the buds of grafts from American stocks, especially when they are earthed up.

The effect is felt in twelve hours, but it does not last long, and the altises return if the treatment be not repeated up to the time the plant need no longer fear their attack. A mixture of naphthalene, sand, or dry earth may be spread on seedlings with the same success. Naphthalenized sawdust is much used to destroy altises of kitchen gardens. It is made by dissolving 10 lb. of naphthalene in ½ gallon of coal tar, then pouring the solution obtained on 20 lb. of quicklime previously slaked with water. After thinning the whole down in 15 gallons of water the sawdust is drenched therewith.

Crude naphthalene was used in Alberta on rows of onions infested by *Hylemyia antiqua*, Meig. (onion maggot). The mixture of naphthalene and furnace ash was worked into the soil close to the plants and killed 80 per cent. of the maggots in 4 days.

*Gryllotalpa vulgaris* (mole cricket).—To drive it off it suffices to bury a little naphthalene in the ground as it is being tilled.

*Ants.*—Sow a mixture of naphthalene and lime where necessary.

*Anthomyia antiqua*, Meig. (onion fly).—Sawdust (naphthalenized) or naphthalene buried in the soil when the onions are planted drives off the fly from these plants and prevents them from laying their eggs.

*Tinea granella*,[1] L. (grain mite); *Ephestia Kuehniella* (flour mite).—The grubs of these tinea cause considerable havoc; the first in granaries, and the second in flour mills. They may be removed by spreading naphthalene in the stores. Seed-corn may be mixed with naphthalene without prejudice to its germinative capacity, but its action is less efficient than that of carbon disulphide, and naphthalene cannot be put in contact with flour to be used as food.

*Carpocapsa pomonella* (codlin moth).—Taschenberg recommends to hook on to the tree rags steeped in naphthalene to prevent the females from laying their eggs on the young apples.

*Cochylis ambignella*, Hubn. (cochylis of the vine).—Pradel advises simultaneous treatment of oidium and cochylis by a mixture of sulphur 9 lb. and naphthalene 1 lb. Dufour has, however, shown that the vapours and the soapy emulsions of naphthalene did not have much action on the caterpillars of the cochylis. This treatment, which has, however, given satisfactory results on the large scale, would only drive away laying females and cause the grown caterpillars to fall to the ground. Dr. P. Cazeneuve found that all the methods of treatment against this insect, pyrethra, soapy emulsions of turps, and petroleum, yield inferior results to the sulphur and naphthalene mixture. Spraying on the grapes is done by a mechanical sulphurator as soon as flowering commences. Some caterpillars already on the grapes quit them precipitately after this naphthalenized sulphurating, the odour of which is repugnant to them. The last treatment is given between 1 and 10 August to combat the second generation of the cochylis. The taste of naphthalene in the wine is not to be feared, because there is no adherence; it is washed off by the rain. When oidium is not to be combated sulphur may be replaced by talc or plaster. To make an intimate mixture of talc or plaster it must be passed through a crushing mill (edge runners or flat stones ?).

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[1] Tinea Granella (tinea of grain).—The tinea of grain causes damage during the first fortnight of August. The female seeks the wheat granaries, there to lay its eggs on the grain. The caterpillars, known as the white-worm of wheat, hatch in eight to ten days and attack several grains at a time, uniting them by a tissue, in the shelter of which they gnaw them on the outside.

*Aphides.*—Taschenberg advises to project a mixture of 1 part of naphthalene with 2 parts of ashes or plaster. The moment is chosen when the leaves are moist with dew, or this treatment is preceded by spraying with water.

*Schizoneura lanigera*, Hausm. (woolly aphis).—Solutions of 1 part of naphthalene in 8 parts of benzene or alcohol (say 1 lb. to gallon) are used in summer to destroy the woolly aphis. The nodosities are coated with the brush. Better results are got with a solution of 5 lb. of naphthalene in 10 gallons of burning oil. The asphyxiating action of this oil makes itself felt at the same time as the insecticidal action of naphthalene. Guozdenovic destroys the woolly aphis by a mixture of tobacco extract 15 lb., soft soap 10 lb., naphthalene $\frac{1}{2}$ lb., in 100 gallons of water, to be used by spraying on the colonies.

*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—Mouillefert found that naphthalene had no action on this pest. Trials made on the large scale by placing naphthalene in proximity to the contaminated roots gave negative results; however, a German patent advises to destroy this louse to drench peat with naphthalene carbon disulphide or tar, and to bury it near the infected stocks. If it is asserted that naphthalene cannot destroy the perfect insect on the roots, it has been shown that Balbiani's ointment (mixture of naphthalene, tar and lime) destroys the winter egg, laid on the aerial part of the plant. The treatment is recommended, both to obtain immunity from the phylloxera in non-infected districts, and as an aid to the underground treatment of insects. Henneguy, who is a zealous advocate of this process, declares that the coating applied preventively on non-infected vines suffices to preserve them from phylloxeric invasion. Coating is done by a painter's brush or by a whitewash brush. The whole wood of the stem is coated all over the surface of the stock, taking no notice of buds and cut sections. The work is done preferably after the pruning of the vine during the whole winter. The best time, however, is the month of February, when the egg's time is up and the louse is hatched. As there are always some winter eggs which escape this treatment, the process is not efficient and useful, unless used concurrently with treatment underground by carbon disulphide.

*Coccides* (cochineals, kermes).—To destroy the cochineal of the vine, scraping and barking play a great part. They are crowned with success if this mechanical treatment be followed by coating with Balbiani's ointment, the insecticide action of which has been shown by Couanon. It is especially energetic at the time the larvæ are hatched. Guozdenovic obtained at the Experimental Station of Spalato in Austria good results against *coccides* by spraying with an emulsion consisting of tobacco extract 5 lb., soft soap $2\frac{1}{2}$ lb., finely pulverized naphthalene $\frac{1}{10}$ lb., in 50 gallons of water.

*Phytoptus piri* (gall mite of the pear-tree).—Erinose of the pear-tree may be overcome after decortication by coating the trunk and the branches with Balbiani's mixture.

*Tetranychus telarius* (red spider).—Viala and Valery Mayet have recommended the decortication of the stocks followed by coating with Balbiani's mixture.

**Cresylic Acid.**—Woodlice in glass-houses may be destroyed by spraying thoroughly the soil, walls, and woodwork with the following mixture: Cresylic acid (pale straw 97—99 per cent.), 1 gallon; potash soft soap (household), 8 lb.; pure naphthalene, ½ lb. These are heated together in a bucket till the soap is melted and the naphthalene dissolved. For spraying, 2 pints of the mixture are used to every 12 gallons of water.

# CHAPTER XXII

## CARBON COMPOUNDS (*continued*)—TERPENES—OLEO RESINS—GALIPOT—TURPENTINE—ROSIN—ROSIN SOAPS—ROSIN EMULSIONS—METALLIC ROSINATES—COPPER ROSINATE—CAMPHOR

*Terpenes.*—Terpenes are met with in many essences and balsams of which they form the liquid part. The different pines and spruces, the junipers and plants of the family of *Terebinthaceæ*, segregate them in the vacuoles of their liber.

**Turpentine.**—Turpentine is the resinous sap [1] (*suc resineux*) which flows from incisions made on trees of the conifer family and terebinth family. The name of galipot is given to the partially solidified resin which forms long tangles along the bark. These resinous saps [oleo resins is the better term] are very complex mixtures. The crude matter distilled either directly or in a current of steam furnishes about 15 per cent. spirits of turpentine; the residue forms rosin of a very complex nature. [The chemical technology of rosin is fully described in McIntosh's "Varnishes," Vol. III., Scott, Greenwood & Son, and the maker of insecticide emulsions should consult that section of the book, which deals with rosin and turps with profit.—(Tr.).]

In the air terebinthene (pinene), which is the hydrocarbon (terpene) of spirits of turpentine, becomes viscous and resinifies; first the oxygen combines in an unstable way with the terebinthene (pinene), which under these conditions acquires oxidizing properties similar to ozone, and thus antiseptic and disinfectant. Turpentine and rosin are insoluble in water, but they contain saponifiable principles which have led to the manufacture of resinous soaps greatly employed in aboriculture.

**Action on Plants.**—The different principles of turpentine are injurious to plants. Spirits of turpentine (*turps*) 2—5 fluid oz. per 6½ gallons bulk of soil is already very poisonous to plants, especially the vine. The aerial organs touched by spirits of turpentine emulsions are damaged, and the spraying of the trunk of vines causes burns. Turps appears more dangerous to the plant than petroleum; resins are more poisonous than tar.

**Action on Insects.**—The products contained in turpentine have a very pronounced destructive action on insects. Turpentine [? turps or oleo resin] spread on the agglomeration of eggs of *Ocneria dispar* (gipsy moth) acts as efficiently as tar.

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[1] Turpentine is not the sap or juice of the tree. It is an oleo-resinous exudation and bears a somewhat similar relation to true sap as sweat does to the blood. Spirits of turpentine is often but most erroneously designated as "turpentine," a term to which it is no more entitled than starch is to being termed wheat or potatoes.—Tr.

**Use.**—*Spirits of Turpentine* (turps).—Turps is never used alone if it be not to destroy the agglomeration of eggs of certain butterflies (*Ocneria dispar*, gipsy moth). It is used in emulsion with water or soap solution, most often with carbon disulphide, milk, or tar.

*Cochylis ambiguella*, Hubn. (cochylis of the vine).—In Dufour's insecticide turps replaces pyrethra powder, which is difficult to procure fresh. Dufour dissolves 30 lb. of soft soap in hot water, adds cold water to make 100 gallons, and incorporates 2 gallons of turps in this soap solution, then emulsifies the whole with a spraying machine. It is necessary to use 13·2—35·2 gallons per acre.

*Schizoneura lanigera*, Hausm. (woolly aphis).—A mixture containing turpentine [oleo resin] has been elaborated by Goldi, and is in common use against the woolly aphis. This mixture has the following composition : Fresh milk 60 per cent., turpentine [oleo resin] dissolved in turps 20 per cent., carbon disulphide 20 per cent. In a stoppered bottle this mixture keeps a long time. The aerial colonies are coated with a brush. To disinfect roots, the following mixture must be used : Milk 60 per cent., turpentine 30 per cent., carbon disulphide 10 per cent.

*Grafting Wax.*—To cover the wounds after destroying the insect grafting wax is recommended (rule in force in the Canton of Argovy in Switzerland), consisting of Venice turpentine 65 per cent., turps 20 per cent., ochre 20 per cent., or 75 per cent. of turps and 25 per cent. of tar.

*Phylloxera vastatrix*, Pl. (phylloxera of the vine).—Mouillefert examined the action of turps on the phylloxera, and found that it was very pronounced. If it perfectly destroyed the phylloxera, on vine roots planted in pots, it was not the same on the large scale. By treating the stocks with 400 cubic centimetres of turps emulsified with water, and sprinkled afterwards with water, and bringing the earth back around the stripped stocks, this product has proved powerless to destroy the insect in the lower reaches of the soil. The coating of the trunk and the roots of the phylloxera-infected vine with 50—100 cubic centimetres of turps (Sans process, 1872) has given no favourable result.

*Coccus.*—Hoffmann recommends to render soapy emulsions more energetic against coccides to add carbon disulphide or turpentine (? turps). An emulsion of 2 per cent. soft soap and 2—3 per cent. of turpentine (? turps) gives excellent results.

*Moles.*—To drive away moles, it suffices to pour water in their burrows, and to lower a cup containing a mixture of petroleum and turpentine.

**Pine and Spruce Resin** [? *Rosin*].—These are used in : (1) Soap emulsions ; (2) the preparation of coatings and bird-limes ; (3) in cupric bouillies to render them more adherent. The resins [? rosins] are used as such or saponified.

(1) **Saponified Resins** [rosin soaps].—**Preparation.**—Several methods are used in America[1] :—

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[1] These formulæ are given in the original French edition of this treatise in metric weights and measures. But the author seems to forget that an American gallon is only five-sixths of an Imperial gallon. In America the pound is not the

1. Dissolve 1 lb. of 98 per cent. caustic potash in 4 gallons of water; add thereto 9 lb. of rosin, heat until complete solution is effected and make up to 10 gallons by adding the necessary water. The brown liquid so obtained is translucid.

2. Boil together for one hour 7 lb. of 70 per cent. caustic potash, 25 lb. of rosin, and 3 lb. of fish oil, with 10 gallons of water. As soon as the mass rises and becomes frothy, stop the boiling and make up with water to 100 gallons (Coquillet). This bouillie is the classic rosin bouillie of America. The following formulæ are now in use. Formula A: caustic potash, 70 per cent., 6 lb., rosin 25 lb., fish oil 3 lb., water 10 gallons. Formula B: caustic potash, 70 per cent., 10 lb., rosin 35 lb., fish oil, 5 lb., water 10 gallons. Formula A is used in summer, thinned down according to the sensitiveness of the tree, with seven to nine times its weight of water. Formula B is only used in winter when the sap is dormant.

3. 16½ lb. rosin, 2½ lb. caustic potash, 98 per cent., and 2½ lb. of fish oil are heated together and then dissolved in 10 gallons of water.

4. 16 lb. rosin, 4 lb. 98 per cent. caustic potash, 2½ lb. of fish oil are melted together, and boiled in 10 gallons of water, cooled, and 4 gallons of water added. Before use 1 part is diluted with 9 parts of water.

5. Dissolve 8—10 lb. of commercial rosin soap in 10 gallons of water.

**Insecticide and Disinfectant.**—If crude phenols, cresols or heavy coal tar oils be mixed with rosin soaps, they furnish a homogeneous product capable of emulsifying with water. For example: 80 parts of rosin, 10 of carbonate of soda, 5 of caustic soda and 300 of water are boiled until completely dissolved. The rosin soap settles out on cooling, or may be salted out from the hot liquor. The well-drained soap is dissolved, in the proportion of 150 parts to 200 parts of heavy coal tar oil, and this forms a stable emulsion in water.

**Action on Plants.**—Soap solutions of 0·8—1·0 per cent. strength do not injure the leaves. A bouillie six times stronger than Formula A used warm in December and January, resulted in the total absence of flowers in the spring.

**Action on Insects.**—Rosin emulsion acts very energetically on insects owing to its causticity; it acts by contact and it forms besides on the insect which it has drenched an impermeable coating which causes asphyxia.

**Use.**—Rosin bouillies are much used in America against caterpillars, and especially against coccides; they replace petroleum emulsions. They give very good results in countries where the prolonged absence of rain assures the efficiency of the treatment for a long period, and where the multiplication of the coccis, owing to the heat, goes on almost without interruption the whole year round. Petroleum emulsions are preferable in districts where rain is frequent. When a resinous bouillie is used on a tree invaded by coccides the bark of the tree must, as far as possible, be entirely drenched. In temperate countries two or three applications must be made at eight days' interval,

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tenth part of a gallon but three-twenty-fifths. Had the author made allowance for the American gallon it would have been impossible for him to have got the French quantities in such round numbers to the litre.

and preferably at the time when the mobile larvæ circulate in quest of a spot on which to fix themselves. The treatments do good on deciduous trees. When the tree is much attacked it must be severely pruned before spraying. To give all its efficiency to the winter treatment, a dose six times stronger must be used than in summer, when, on the contrary, the bouillie made from No. 2 formula is thinned down with nine times its volume of water.

By this process, and with the emulsion from formula No. 4, Swingle and Webber destroy the following caterpillars and lice: *Ceroplastes fluoridensis*, *Dactylopius citri*, *Aphis gossypii*, Glover; *Lecanium oleæ*, *Icerya purchasi*, *Aleyrodes citri*. Gossard used with great success an emulsion of ground rosin 16 lb., caustic soda, 98 per cent., 3·4 lb., fish oil 2½ gallons, water 100 gallons, applied in winter when the cochineals are in the larva state. Marlatt recommends to destroy *Aspidiotus aurantii*, Mask, *Aspidiotus citrinus*, Coq., the summer bouillie formula No. 2 A. A bouillie four times stronger kills 85 per cent. of *Aspidiotus perniciosus*, Comst. (San José louse), *Phorodon humuli* (hop aphis). It does not stand spraying with a solution of rosin soap, formula 5.

*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—Koebele's trials were a failure. Emulsions do not penetrate the soil sufficiently and do not reach all the phylloxeras. Only the insects touched die.

*Aspidiotus uvæ*, Comst., on vine.—Galloway's bouillie No. 3 is recommended for its destruction.

*Tetranychus telarius* (red spider).—Bouillie No. 3, diluted with 3—4 parts of water, is recommended to destroy it.

(2) **Compositions and Bird-limes** (*Enduits et glus*).—Formulæ for preparing coating compositions: 1. 200 oz. spruce resin (*resine de sapin*, ? Burgundy pitch) are heated over a gentle fire until fused, then 5 oz. of linseed oil and 10 oz. of honey added; when the mixture is homogeneous it is removed from the fire, cooled, and 28 oz. (wt.) of 90 per cent. alcohol added. This coating should be kept out of contact with air; it is used cold.

2. 500 oz. of spruce resin are fused and dissolved in 75 oz. (wt.) of 90 per cent. alcohol; 4 oz. of gum-arabic dissolved in very little water are added, and 20 oz. of carbonate of soda.

3. Melt together equal parts of rosin, wax, and turpentine. This composition is applied hot.

*Bird-limes* are made as follows: 1. Heat together and reduce to two-thirds of the original volume 2½ lb. of colza oil and ½ lb. lard, then add whilst stirring ½ lb. of turpentine and ½ lb. of rosin. The consistency should be syrupy; if it be too fluid the heating is to be continued, if it be too thick more oil is added. This bird-lime remains sticky for three months.

2. Heat together 5 oz. of rosin, 4 oz. of stearine, and 4 oz. of lard.

3. Heat together 5 oz. of rosin, 2 oz. of lard, and then add 1 oz. of turpentine, and then 2 oz. of stearine; boil to a suitable consistency.

4. Heat with care 7 lb. of wood tar with 5 lb. of rosin; when the whole is fused add 5 lb. of soft soap, then 3 lb. of cod oil; remove from the fire and stir till cold.

**Use.**—Cold coating compositions (*Enduits*) are used to protect young buds from insects. Sorauer advises to cover them with a thin layer which, whilst it drives off insects, does not prevent the normal evolution of the bud. It is an effective protection against *Tortricides*, *Tineides*, as well as against weevils: *Otiorhynchus*, *Magdalis*, *Peritelus*, and others. To prepare a very thin coating Henschel recommends to dilute it previously with alcohol. Cold or hot coatings are used with success to cover the wounds of trees.

Bird-limes have found a current use in replacing tar rings. Rings of bird-lime are applied about 5 feet above the surface of the ground. It may be applied directly on the bark of old trees. With young trees the treatment is risky. Hartig and Sorauer found that thin-barked young trees are sensitive to bird-lime, and the bark, being penetrated by it, the tree dies in a few years. When young trees are to be protected, the trunk of the tree is encircled by a band of paper 11 centimetres (say 4½ inches) wide, which is coated with bird-lime. It is well to keep the ring on all the year round and to renew it whenever it loses its stickiness, say about every three months. The ring of bird-lime is much more effective than the classical tar ring; like the latter, it retains all the apterous insects which ascend from the soil on to the tree by the trunk, or which descend by the same road to metamorphose in the soil. Thus the *Cheimatobia brumata*, L., and the *Hibernia defoliaria*, L., apterous phalena, the larva of *Eriocampa adumbrata*, and the *Psylla* of the pear-tree are easily destroyed in that way.

*Schizoneura lanigera*, Hausm. (woolly aphis).—To combat this aphis Clarac recommends to coat the spots invaded by colonies, that is to say, all the bark, by a mixture made by heating 2 lb. of tallow, 3 lb. of rosin, 5 lb. of poppy or colza oil.

(3) **Bouillies.**—Rosin is added to increase the adherence of a copper bouillie. The following formulæ may serve as a guide: 1. Blue vitriol 12 lb., lime 15 lb., rosin 6 lb., soap 7 lb., water 100 gallons. 2. Blue vitriol 12 lb., rosin 15 lb., soap 6 lb., water 100 gallons.

**Camphor,** $C_{10}H_{16}O$.—**Natural Occurrence.**—Camphor is extracted in China and Japan from old camphor trees, *Laurus camphora*, by sublimation—heating the roots and branches. It is refined in Europe by fresh sublimation.

**Properties.**—Camphor is a white, semi-transparent, crystalline substance. It has a characteristic, fresh, aromatic odour. Its density is from 0·992 at 10° C. It melts at 173° C. and boils at 204° C., but it volatilizes perceptibly at the ordinary temperature. Water dissolves 1 part in 1300 at 20° C. Alcohol and oils dissolve it freely. Camphor is a poison of the protoplasma; even in dilute solution its antiseptic power is known. It has been used from the most remote times. It has a poisonous action on the lower animals, chiefly the arthropodes, which are killed by the vapours emitted by camphor at the ordinary temperature.

**Use.**—*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—From 2—3 grammes of camphor run into a hole dug by a gimlet, as far as the pith of the stock, and then corked, had a certain action on the phylloxeras of the roots, but destruction was incomplete (legal process, 1872). Watering the ground round the stem with a bouillie of 10 lb. of camphor, 25 lb. of ammonia, and 25 lb. of lime, had no good effect.

**Mice.**—To protect seed-corn from mice it suffices to mix it with a little camphor before sowing it. The smell drives off the rodents.

# CHAPTER XXIII

CARBON COMPOUNDS (*continued*)—NITROBENZENE—CARBOLIC ACID—PICRIC ACID—CRESOL—SAPOCARBOL—CREOSOTE—CREOLINES—LYSOL—POTASSIUM DINITRO-CRESYLATE—THYMOL—$\beta$-NAPHTHOL METHYL VIOLET.

**Nitrobenzene,** $C_6H_5NO_2$.—**Preparation.**—By pouring very slowly, whilst stirring, 1 part of benzene into a cold mixture of 2 parts of nitric acid of 40° Bé., and 2 parts of sulphuric acid of 66° Bé. When nitrobenzene is formed water is added till it separates. It is decanted and washed several times with pure water, then with water to which a little carbonate of soda has been added.

**Properties.**—Nitrobenzene is a yellowish liquid boiling at 213° C., of a sweet taste, having the smell of bitter almonds. It is insoluble in water, but soluble in alcohol, benzene, and oils. It is poisonous ; the poisonous symptoms are the same as those produced by aniline cyanose. The fatal dose for a man is 8—9 drops (Letheby), 20 drops (Bardt).

**Action on Plants.**—The experiments of Papasogli, Tergioni-Tozzetti, and Del Quercio, have shown that soapy emulsions containing 0·5—0·75 per cent. of nitrobenzene, and soapy and alcoholic emulsions containing 0·25—0·5 per cent., are not injurious to plants. Zechini and Silva found, on the other hand, that a 2 per cent. nitrobenzene emulsion is very injurious to the vine.

**Action on Insects.**—Nitrobenzene poisons insects. From the author's experiments the nitro group would appear to increase appreciably, and in a general manner, the toxicity of aromatic compounds. Papasogli found that a milligram of nitrobenzene, evaporated under a cloche, killed all the eggs of the fly and of *Bombyx mori*. According to the author's experiments nitrobenzene prevents the hatching of chrysalides.

**Use.**—Papasogli recommends to destroy soft-skinned insects and plant lice by an emulsion prepared thus : Dissolve 50 lb. of nitrobenzene in 150 lb. of amyl alcohol, and add thereto 100 lb. of soft soap. This insecticide is thinned down before use, and according to the sensitiveness of the plant, with 10—20 parts of water, so as to get an emulsion containing nitrobenzene 0·84—1·7 per cent., soft soap 1·7—3·4 per cent., amyl alcohol 2·6—5·1 per cent.

*Agrotis segetum* (grey-worm).—Papasogli recommends to water beets with an emulsion of 5 lb. of nitrobenzene, 5 lb. of sulphuric acid, in 9 gallons of water, to kill the grey-worm, the caterpillar of this noctua.

*Cochylis ambignella*, Hubn. (cochylis of the vine).—The caterpillar is killed by an emulsion containing 2 per cent. of nitrobenzene; but of that strength the insecticide is prejudicial to the vines. Dufour also found that the maximum strength of a soap emulsion of nitrobenzene should be 2 per cent. nitrobenzene and 3 per cent. of soft soap.

*Schizoneura lanigera*, Hausm. (woolly aphis).—Nitrobenzene enters into the composition of an insecticide made in Switzerland, "Knadolin," invented by Kraft and recognized by the Federal Department of Agriculture for the destruction of the woolly aphis. It consists of 2 lb. of nitrobenzene, 1 lb. of potassium xanthogenate, 40 lb. of soft soap, and 60 lb. of amyl alcohol. It is not used in the commercial condition but in aqueous solutions. With 1 lb. of Knadolin one can, according to the effect desired, prepare 1—4 gallons of liquid insecticide. It immediately moistens all the substances which it touches, which renders it superfluous to clean the trunk mechanically previously. To make sure of killing well-hidden insects, it is well, against colonies of woolly aphis, to use the insecticide only diluted with fifteen times its volume of water. Goethe remarks that Knadolin does not attack the shoots and leaves of trees like sapocarbol and lysol.

*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—Papasogli recommends a mixture of 5 lb. of nitrobenzene, 5 lb. of sulphuric acid, 9 gallons of water, for the destruction of this plant louse (1876—1880). The mixture is run into channels 8 inches deep between the stocks, and closed up forthwith.

*Coccides of the Olive-tree.*—Mottareale advises for their destruction an emulsion which he regards as very efficient, consisting of nitrobenzene 0·25—0·5 per cent., soft soap 0·25—0·5 per cent., water 99·50—99·75 per cent.

**Carbolic Acid,** $C_6H_5OH$.—**Preparation.**—Carbolic acid or phenol is obtained from coal tar, in which it is present to the extent of 3—12 per cent. When tar is heated carbolic acid distils, at the same time as middle oils, between 150° and 200° C. Strong caustic soda is added to these oils, in which carbolic acid and its homologues dissolve. The liquid is treated by five times its weight of hot water; the phenols dissolve in the water, whilst the hydrocarbons remain insoluble. To obtain carbolic acid it suffices to treat this liquor by dilute sulphuric acid, and to decant. Crude carbolic acid, containing its homologues, is thus obtained. To purify it, it is washed with water, dried, then distilled in cast-iron retorts, collecting the portion which passes between 180° C. and 190° C., and crystallizing. Rectification is not required in the case of carbolic acid used as an insecticide, for the homologues of carbolic acid are as insecticidal as itself.

**Properties.**—Carbolic acid is a solid body, colourless in the pure state, crystallizing in long needles. The slightest trace of water liquefies it. It is soluble in twenty times its weight of water, and volatile at the ordinary temperature. It possesses a special odour and a burning taste. Carbolic acid is a powerful antiseptic, but it is also poisonous and caustic. It coagulates albumens.

**Action on Plants.**—*Injurious.*—Nessler has shown that young plants die if an amount of carbolic acid more than 0·012 per cent. be added to their nutritive medium, likewise if pot plants be watered with a solution of 0·3 per cent. strength. A solution of 1 per cent. is pernicious to cherry-tree and peach-tree leaves. Used to disinfect corn-seed it does not lower the germinative capacity.

**Action on Fungi.**—As determined by Bull it requires a 5 per cent. solution of carbolic acid to coagulate the white of egg, gelatine, and casein; the precipitate is not a chemical derivative but a dehydrated albumen, the carbolic acid being capable of being removed by washing. The action of carbolic acid on the spores of fungi ought, therefore, to be less energetic and more uncertain than that of copper salts which yield with albumens stable insoluble compounds. The effect of carbolic acid on saprophytic fungi such as *Penicillium glaucum* has been studied by Plugge. A solution of 1—1·5 per cent. kills them. According to Neumann a 0·1 per cent. solution in no way hinders the germination of their spores, a 0·2 per cent. solution retards this germination, and a 0·3 per cent. solution acting several times on the spores ends up by killing them. Lemaire prevents the moist mould of flour by a 5 per cent solution. Ferments are affected as follows by carbolic acid: A solution of 1—2 per cent. strength interferes with the fermentation. A solution of 5 per cent. strength prevents it. The action on bacteria is pronounced. Bucholz has shown that if a solution of 0·5 per cent. strength interferes with their development, a 4 per cent. solution prevents their multiplication.

**Action on Insects.**—Carbolic acid is poisonous to insects; its property of coagulating albumen puts it on the same plane as metallic salts endowed with the same property, *e.g.*, salts of copper, silver, and mercury, but this action is weak. As Bull has shown, a solution of 5 per cent. strength coagulates white of egg, a 3 per cent. solution only renders it turbid, and a 1 per cent. solution leaves it limpid. Gelatine and casein behave in the same way. According to Perroncito, the eggs of *Bombyx mori*, L., still hatch after steeping two hours in a 1 per cent. solution of carbolic acid.

**Use.**—Carbolic acid has found several uses. It is used in aqueous solution, in soapy emulsions, in admixture with silicate of soda, in absorption by sawdust, by injection into the sap of plants, and in spraying.

**Use as Weed Killer.**—Pammel recommends a 25 per cent. emulsion of carbolic acid in water to destroy *Cnicus arvensis* (charlock of Canada). The plant is cut 8 inches underground and the young shoots produced are washed afterwards with the emulsion.

*Phoma betæ* (disease of the leaves of the petiole of the beet).—Carbolic acid plays the preponderant rôle in the disinfection of beet seeds against bacterian and cryptogamic diseases. Kruger asserts a 1 per cent. solution acts more surely than steeping for twenty hours in a 0·4 per cent. solution of blue vitriol; for forty-eight hours in a 2 per cent. Bordeaux bouillie; for eight hours in a 0·02 per cent. mercuric chloride, and yet it does not lower the germinative capacity of the seeds. The first experiments of 1890 made by Hellriegel consisted in steeping for twenty hours in a 1 per cent. solution of carbolic acid. They yielded as a result of twenty experiments, 98 per cent. of sound beets against 13 per cent. for the untreated. Steeping twenty hours has been found too long, because it causes a delay of fifteen days in the germination of the seed. By limiting the steep to fifteen hours, even whilst using a 0·5 per cent. solution, the result is the same, but seeds withdrawn after ten hours only gave 50 per cent. of sound plants. To facilitate disinfection, Carlson advises to soften the seed for three days in pure water of 17·5°—19° C., and only put them in the carbolic acid afterwards, when it acts quicker. Tarschebinski has made numerous experiments which have confirmed those of Carlson. He found that corrosive sublimate disinfected beet seeds without previous steeping in water. Carbolic acid does not completely disinfect until after steeping of the grain; without that precaution disinfection is only relative. He also found that carbolic acid destroyed the spores of fungi much easier than bacteria. Wilfarth and Wimmer believe that carbolic acid must be completely soluble in water to give favourable results, and for that reason they prefer the crystallized acid of commerce.

**Method of Disinfection.**—After having perfectly dissolved the carbolic acid in water the seeds are added; they are stirred energetically to moisten them uniformly; the seeds are then pressed by boards and weights so that they are entirely covered with liquid disinfectant. After twenty hours' steeping the seeds are withdrawn and spread out in thin layers in an airy place, where they are frequently turned. The seeds so dried may be preserved as long as desired without that being injurious to them. Mark advises for the disinfection a mixture of carbolic acid and blue vitriol.

*Potato Scab.*—Frank and Kruger tried to disinfect the soil with carbolic acid to overcome this bacterian disease of the potato. They used an emulsion containing 250 grammes (0·55 lb.) of carbolic acid and 500 grammes of soap for a plot of 4 square metres. The result was not so good as in disinfection by petroleum.

*Bacillus solanacearum* (bacterial disease of Irish potato, and egg plant, *Solanum melongena*).—Sackett recommends the disinfection of potatoes and tomato seed by a 5 per cent. solution of carbolic acid.

*Rhizoctinia violaceæ betæ.*—Eriksson found that disinfection of the soil by carbolized lime appreciably diminished the number of these fungi.

*Uncinula americana*, How. (oidium of the vine).—Vesque, after experiments to overcome oidium, found that carbolic acid of less strength than 1 per cent. does not destroy oidium, whilst 0·1 per cent. solutions are injurious to grapes.

**Use against Insects.**—*Melolontha vulgaris*, L. (cockchafer).—To preserve strawberry plants from the larvæ of the cockchafer, it is advised to till along the borders and to sprinkle the hollows with a 0·1 per cent. solution of carbolic acid.

*Magdalis ænescens*, Lec.—Against this insect, which lives in the bark of the apple-tree on the Pacific coasts, Chittenden advises to coat the trunk in the springtime, up to end of May, with an emulsion of carbolic acid, lime, and soap.

*Anthonomus pomorum* (apple blossom weevil).—Whitehead recommends against this insect spraying with a solution of soft soap 5 lb., carbolic acid 5 lb., in 100 gallons of water.

*Tomicus dispar*, Fbr. (" apple bark beetle," " shot-borer," " pear blight ").—In Canada this insect is prevented from laying its eggs on the trunk of fruit trees by spraying on the trunks in spring a dilute solution of carbolic acid.

*Halticineæ* (altises).—To protect young kitchen garden plants against the attacks of altises, spraying with very dilute carbolic acid is recommended.

*Atomaria linearis*, Steph.—To drive off this insect from young beet plants, it suffices to disinfect the seeds as indicated on p. 379.

*Eurydema ornatum*, L. (decorated bug).—The red cabbage bug is overcome by dusting the leaves with sawdust steeped in carbolic acid.

*Cossus ligniperda* (the goat-moth).—Inject carbolic acid into the tunnels and stop the orifices.

*Hyponomeuta malinella*, Zell. (small ermine moth of apple-tree).—In Italy 2 per cent. tobacco juice, strengthened by a little carbolic acid, is used to destroy the caterpillar of this butterfly.

*Plusia gamma*, L. (*gamma* moth of the cabbage).—Ashmead advises to dust the cabbage for two to three days with a mixture of phosphate of lime 20 lb., powdered lime 3 lb., carbolized sawdust 1 lb.

*Schizoneura lanigera*, Hausm. (woolly aphis).—Muhlberg found that carbolic acid in this form, carbolic acid 4 lb., silicate of soda 100 lb., a mixture yielding an adherent jelly, kills the woolly aphis.

*Chermes piceæ* and *Mindarius abietinus* (cochineals of the spruce).—Boas got appreciable results by spraying with a solution containing 1—2 per cent. of carbolic acid or 3—5 per cent. of lysol.

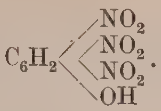
*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—Mouillefert declares that the phylloxera is killed by carbolic acid vapours although slowly and by contact. But carbolic acid is powerless to overcome the phylloxera on the large scale. All the methods tried to attain this end have failed; the Quehen-Mallet process, with a 0·2 per cent. solution of carbolic acid; the Leonhardt process, using strong carbolic acid, laid in holes pierced around the stocks, and the Anatole process, spraying the soil round the stocks with an emulsion of petroleum and carbolic acid, have all been failures. Dr. Manchon tried an original process to poison the sap by making injections of dilute carbolic acid. Theoretically it could be granted that the descending sap carries the carbolic acid to the roots and kills the phylloxera. Henneguy shows that it is not so, as the phylloxera was not killed and the plant perished. A liquid, whether poisonous or not, absorbed by the sap may circulate with it and reach all the organs of the plant; but there are products which may be transformed by the sap itself, and consequently the insecticidal action is not felt in spots distant from the point where they were injected into the plant.

*Limithrips tritici* (onion thrips).—Webster found that a 1 per cent. solution of phenol destroyed this thrips.

*Tingis piri*, Fl. (tiger of the pear-tree).—Dubreuil indicates dilute carbolic acid as efficient against this parasite.

*Psylla mali*, Forst. (chermes of the apple-tree).—It is overcome by a solution of carbolic acid 0·5 per cent. and soft soap 0·5 per cent.

*Eriophyes ribis* (*Phytoptus ribis*, currant gall mite).—It may be overcome by a mixture of carbolic acid 3 gallons, soft soap 30 lb., in 500 gallons of water. First spraying in spring, second in autumn.

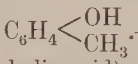
**Trinitrophenol or Picric Acid,**  $C_6H_2\begin{cases}NO_2\\NO_2\\NO_2\\OH\end{cases}$. **Preparation.**—Picric acid is the most important of the nitrated derivatives of phenol (carbolic acid). It is obtained by heating carbolic acid with an excess of fuming nitric acid or by pouring nitric acid drop by drop into carbolic acid dissolved in sulphuric acid. Crude picric acid, which separates from the liquid after cooling, forms crystals which are collected. After draining they are dissolved in caustic soda; the picrate so formed is crystallized and decomposed by sulphuric acid.

**Properties.**—Picric acid crystallizes in yellow plates of a bitter taste soluble in 86 parts of water at 15° C. and in 26 parts of water at 77° C. It dissolves better in alcohol. Its salts are explosive. Picric acid precipitates albumen in the same way as powerful insecticides; it is highly antiseptic.[1]

**Action on Plants.**—Experiments on this point are few; however, trials on the vine show that the vine supports with impunity coatings and washings of its roots. With a dose of 40 grammes per stock (616 grains) there is as yet no posisoning.

**Use.**—Picric acid has been tried in Germany as "Reflorit," comparatively with blue vitriol, but without success, for the disinfection of seed-corn against *Tilletia* and *Ustilago*. The corn was too sensitive to its action. The results obtained by its use against mildew, oidium, cochylis, and chlorosis were negative.

**Action on Insects.**—The first experiments on phylloxera were made by Rommier. He found that by watering a vine in pot with 150 cubic centimetres of water containing 2 grammes of picric acid, all the phylloxera were killed in a few days. Experiments on the large scale did not give such a satisfactory result. Although each stock received 40 grammes of picric acid in solution, although this operation was followed by rains favouring the diffusion of the insecticide, and although the earth was soaked with it to such an extent that it tasted bitter, the phylloxera of the lower layers were still living eighteen days after treatment.

**Cresol or Cresylol,**  $C_6H_4<{OH \atop CH_3}$.—**Preparation.**—Cresol, a methyl derivative of phenol (carbolic acid), is present in coal tar and in wood tar. It is obtained in the distillation of tar at the same time as phenol. Crude phenol is distilled and that which passes between 200° C. and 205° C. is collected. It is an oil consisting in great part of cresylol.

**Properties.**—Cresylol does not combine so readily with alkalies as phenol, and is less soluble in water. It is an oil which has much resemblance with carbolic acid in physical, chemical, and antiseptic properties.

**Commercial Preparations containing Cresylol.**—Cresylol is rarely used as such, but mostly as its sodium derivative. It is an ingredient of the best known and most efficient insecticides. These are the

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[1] *Translator's Note.*—All nitro derivatives and their metallic salts, more espcially picric acid and picrates, are highly explosive, and their storage is attended with extremely great danger. A special licence is required.

"sapocarbols," mixtures of crude cresylol and soap; the "lysols," mixtures of tar [oil] and soap; the "creolines," of analogous composition; "solutol," containing 15 per cent. of cresylol, 45 per cent. cresylate of soda, in presence of an excess of alkali; "solveol," of analogous composition but neutral; "amylo carbol," consisting of 150 oz. of black soap, 160 oz. of amyl alcohol, and 9 oz. of cresylol; "thymokresol," prepared in America; "beech tar creosote," which contains along with phenol, phorol, guaiacol, cresol, much cresylol. The composition of these various insecticides differs greatly. They contain more or less cresylol according to the source of the tars or the crude cresylols used in their preparation. Like carbolic acid they all act on insects and on plants, an action, however, which is more energetic but which varies much from one product to another, according to the source of the cresylol. There is thus much difference between the doses recommended as killing insects without injuring the plants.

**"Sapocarbol."**—This product, made in Germany,[1] is a solution of homologues of carbolic acid in soaps. It is made by heating a mixture of linseed oil, rosin, and potash, and the oils collected in the distillation of crude carbolic acid, between 190° C. and 205° C., oils which contain 10 per cent. of cresylol, along with xylenol, guaiacol, and other phenols. Alkali does not enter, except in the small amount required to saponify the vegetable oils, in such a way that the "sapocarbols" may be regarded as solutions of cresylols in soaps. There are several brands of "sapocarbols." Their composition, very analogous to that of the lysols, is shown in Engler's analyses. Table LXXIV gives the percentage of active ingredients which they contain.

**Properties.**—"Sapocarbols" are neutral; diluted with water they yield an emulsion from which the aromatic hydrocarbides separate more or less rapidly according to the amount of soap present.

TABLE LXXIV.—*Showing the Comparative Amounts of Active Ingredients in Different Brands of Lysol and Sapocarbol Insecticides.*

| Insecticide. | Carbonate of potash, per cent. | Phenols, per cent. |
|---|---|---|
| Schenkel's sapocarbol No. 00 . . | 2·6 | 37·3 |
| ,, ,, ,, 0 . . | 7·7 | 37·6 |
| ,, ,, ,, 1 . . | 7·6 | 44·2 |
| Lysol No. 1 . . . . . | 5·91 | 44·1 |
| ,, 2 . . . . . | 6·29 | 46·2 |
| ,, pure . . . . . | 6·52 | 47·4 |

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[1] *Translator's Note.*—The manufacture of this class of goods is a British-born industry which originated in the first instance in sheep-dip manufacture. Both "Sapocarbol" and "Lysol" appeared on the Continent very late in the day, and neither their composition nor manufacture is based essentially on any very new principle. The only real distinctive feature is the proprietary name, and if every proprietary mixture of this sort, however meritorious it might be in itself, were to receive the special mention "lysol" and "sapocarbol" do here, the special literature would be more than unwieldy.

**Action on Plants.**—Fleischer found that sapocarbol acted as follows :—

TABLE LXXV.—*Action of "Sapocarbol" on Plants.*

| Plants. | Solution, 1 per cent. | Solution, 2 per cent. |
|---|---|---|
| Plum-tree and apple-tree shoots and leaves . | Nil | Injurious |
| Young shoots of the vine . . . . | Decided | Deadly |
| Adult leaves . . . . . . | Nil | Injurious |
| Nasturtium . . . . . . . | ,, | Nil |

Solutions of "sapocarbol" above 1 per cent. injure most leaves.

**Action on Insects.**—Fleischer examined the action on plant-lice.

TABLE LXXVI.—*Showing the Action of Solutions of "Sapocarbol" on Plant-lice.*

| Insect species. | 1 per cent. | 2 per cent. |
|---|---|---|
| Woolly aphis, isolated . | Killed | Killed |
| ,, ,, in colony . | Partly destroyed | Destroyed almost entirely |
| Plum aphis . . . | Killed | Killed |
| Apple ,, . . . | ,, | ,, |

Siedler, also Koebele, regard a 1—2 per cent. as sufficient to destroy all plant lice. Fleischer and Keller recommend sapocarbols to kill plant lice, and even the woolly aphis; in spring, by coating the nodosities with a 2—3 per cent. solution, by 1 per cent. spraying in summer.

**"Creolines."**—Various "creolines" are differentiated :[1]

*Pearson's "Creoline"* is the product obtained by the saponification of a mixture of higher phenols and coal-tar oil containing a small quantity of pyridine bases.

*Artmann's "Creoline."*—Contains hydrocarbides extracted from coal tar and completely freed from phenols, German patent 51515. Whilst Pearson's "creoline" contains, along with 57—60 per cent. of hydrocarbides, 22—27 per cent. of phenols, Artmann's "creoline" contains 85 per cent. of hydrocarbides, and only 1·5 per cent. of phenols.

**Properties.**—"Creolines" treated by water yield an emulsion from which the hydrocarbides present therein separate after a certain time. Compared with lysols they have the great drawback of not yielding stable solutions with water. Looking to their different phenol content their action is very variable.

**Action on Plants.**—Fleischer tested the action of Artmann's "creoline" on plants and prepared the following table :—

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[1] *See Translator's Note to "Sapocarbol"* (p. 382).—Jeyes was the first to apply the term "creoline" to the active principle of this type of compound.

TABLE LXXVII.—*Showing the Action of Artmann's "Creoline" on Plants.*

| Plants. | 0·5 per cent. | 1 per cent. | 2 per cent. |
|---|---|---|---|
| Young shoots and leaves of apple | Intact | Attacked | Greatly attacked |
| Young shoots and leaves of rose | Scarcely attacked | Damaged | Greatly attacked |
| Young shoots of vine | Greatly attacked | Greatly attacked | Killed |
| Adult leaves of vine | Intact | Intact | Damaged |
| Nasturtium leaves | Damaged | Greatly attacked | Killed |

**Action on Insects.**—Fleischer tried Artmann's "creoline" on plant lice :—

TABLE LXXVIII.—*Action of Artmann's "Creoline" on Plant-lice.*

| Species. | Action of a solution of | | |
|---|---|---|---|
| | 0·5 per cent. | 1 per cent. | 2 per cent. |
| Woolly aphis, isolated | Nil | Insignificant | Rapid |
| ,, ,, in colonies | Nil | Nil | Partial |
| Willow aphis (naked) | Decided | Decided | Decided |

Goethe found a solution of soft soap better than one of "creoline."

**Use.**—**Disinfection of Seed Potatoes.**—Mohr tried to disinfect seed potatoes with "creoline." By steeping twenty hours in a 0·2 per cent. "creoline" solution germination was retarded ten days. A more concentrated solution had deadly effects. By diminishing the dose to 0·05 per cent. and in adding 1 per cent. of blue vitriol, not only was the germination not retarded, but the crop was heavier, say 35·2 metric tons with 13·9 per cent. of starch against 21·6 metric tons with 17 per cent. of starch.

*Cochylis ambiguella*, Hubn. (cochylis of the vine).—Numerous trials have been made. Zechini and Silva destroyed the vine-worm by a 3 per cent. emulsion. They obtained the same result with an emulsion of 1 per cent. of creoline and 1 per cent. of nitrobenzene. Like Dufour and Fleischer they found this treatment was very prejudicial to the leaves and grapes. They therefore sought to discover other mixtures, such as :—

TABLE LXXIX.—*Showing Composition of "Creoline" Mixtures which gave Good Results against Cochylis.*

| | I. Lb. | II. Lb. | III. Lb. |
|---|---|---|---|
| Creoline | 1·5 | 1·5 | 1·5 |
| Amyl alcohol | 8 | — | — |
| Tobacco juice | — | 4 | 4 |
| Soft soap | — | — | 1 |
| Water | 90·5 | 94·5 | 100 |

These were quite satisfactory. Martini reduced the cochylis 65—68 per cent. by two treatments, one in the end of April, the second in the beginning of May, with an emulsion containing 1·5 per cent. of Nava creoline, 1 per cent. of lime, and 1 per cent. of blue vitriol.

**Creosote** [wood tar].—Creosote is a mixture of different phenols. Chemists who have studied the subject are divided in their opinions as to its constitution. According to Marasse creosote contains phenol, cresol, phlorol, guaiacol, and creosol.

**Preparation.**—Creosote is extracted from wood tar, chiefly beech tar, by distillation. The oily layer of the condensed liquid contains creosote. This oily layer is again distilled, only the portions denser than water are collected. When the product so obtained is treated with a solution of caustic potash the hydrocarbides remain undissolved, whilst creosote dissolves. Creosote is precipitated from its solutions by sulphuric acid. Soot contains a certain amount of creosote.

**Properties.**—Creosote is a refractive, colourless, oily liquid, with a smell of smoke and a burning taste. It does not dissolve in water, but is very soluble in alcohol and in alkaline lyes. Creosote dissolves resins and sulphur, coagulates the albumen of blood and of white of egg. It is a strong caustic and one of the best organic antiseptics, but it has a poisonous action, like that of carbolic acid. It is used in the state of vapour as a meat preserver, and in solution for the preservation of wood, which it preserves both from insects and saprophytic fungi. Its action on plants and insects is very analogous to that of carbolic acid.

**Use.**—*Merulius lacrymus*, Schum. (rot of building timber, dry rot).—" Carbolineum," consisting almost entirely of creosote, is recommended against this fungus.

*Haltica* (altises). -The bad smell of soot causes it to be used to drive away altises. Thiele records several failures. Mohr recommends it as an insecticidal manure. The soot is spread on the field, ploughed in, and crop sown eight to ten days later.

*Sitones lineatus* [1] (striped pea weevil).—It is driven off by spreading soot on the pea and haricot borders.

*Ocneria dispar*, L. (gipsy moth).—The mass of eggs of this butterfly are destroyed in America by the following mixture : Creosote 50 per cent., carbolic acid 20 per cent., tar oil 10 per cent., turps 20 per cent., the latter being chiefly used to dilute the creosote. This method is infallible. Experiments in America on 220 miles of land, by applying creosote on the eggs of this butterfly, followed by spraying with arsenate of lead on caterpillars freshly hatched, were locally crowned with complete success, and exterminated this formidable butterfly until further incursions developed.

*Abraxas grossulariata*, L. (magpie moth).—In America soot is used to destroy the caterpillars of the magpie moth. They pass the winter under the dry leaves underneath the gooseberry bushes. These leaves are removed and the soil round the shrubs covered with soot.

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[1] *Curculio* (*Sitones*) *lineatus* (striped pea weevil).—Injures leguminosæ, especially peas and haricots. The perfect insect gnaws the young leaves in the spring, the larvæ gnaw the roots.

*Agromiza nigripes* (fly injurious to lucerne).—Debray recommends to spread soot on lucerne plants to drive off the female about to lay.

*Aphrophora spumaria*,[1] L. (grasshopper family).—Debray advises to destroy the larvæ in lucerne fields to cut the crop early and to spread soot on the field.

*Schizoneura lanigera*, Hausm. (woolly aphis).—Landry advises the use of the following mixture : Sulphur ¼ lb., soot 5 lb., tobacco juice 3½ lb., water 5 gallons. Apply by brush on nodes and fissures infested by the lice.

*Phylloxera vastatrix.*—Mouillefert remarked the antiphylloxeric properties of creosote, but it does not act on the soil at a great distance, which renders its action uncertain and incomplete ; besides the toxic dose for this pest kills the vine which it should protect. Lustner made experiments to determine if cresols communicate their odour to the vine, and he concluded affirmatively. Wherever cresols were used to replace petroleum in the disinfection of the vine against the phylloxera he found that the grapes possessed the taste of cresols within a radius of 17 metres around the stock treated, a taste which is communicated to the vine in a very marked manner.

*Coccides.*—Hering recommends to destroy these parasites by coating the trunks of the trees in November with pure Carbolineum. This treatment does not damage the bark, but the eyes and the buds touched are destroyed. Graf Wolstein concludes, from numerous experiments, that all trees coated with pure Carbolineum were freed from all parasites animal and vegetable, including *Cossus*, *Scolytes*, and woolly aphis. The gum of cherry-trees disappears rapidly if the treatment is repeated. Spraying with 2, 3, 8, 10 per cent. solutions have no effect except when the solutions are concentrated. Spring 2 per cent. sprayings have no effect.

**" Lysols."—Preparation.**—The preparation of Damman " lysols " consists essentially in mixing in fixed proportions coal-tar oils containing phenol and its homologues, with an oil such as linseed oil or rape oil, or with a resin such as rosin, by adding a base, preferably caustic potash, in sufficient amount to obtain complete saponification. The operation is conducted in presence of alcohol, which hastens saponification and helps to render the " lysols " soluble and to impart to them a suitable consistence. The proportions in the German patent are linseed oil 10 lb., coal-tar oil 10 lb., caustic potash 30 per cent., alcohol 6½ lb. ; or rosin 10 lb., tar oil 4 lb. ? caustic potash 7 lb., alcohol 7 lb. Mix the linseed oil with the tar oil, add the caustic potash, then the alcohol ; the mixture is heated to complete saponification in an apparatus fitted with an ascending condenser.

**Properties.**—" Lysols " are liquid, brownish oils, transparent, and soluble in water. Added to distilled water they form a limpid, mobile liquid, with calcareous water they are turbid. The aqueous solutions do not act on metals. " Lysols " are soluble in all proportions in ethylic, methylic, and amylic alcohol, and may be mixed with benzene. They possess a strong odour of creosote, and the antiseptic properties of phenols without their defects.

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[1] APHROPHORA SPUMARIA. *Hemiptera*, of the grasshopper family, which lays its eggs in the end of autumn in the bark of plants. The larvæ, which hatch in the spring, suck the juice of plants and surround themselves so as to protect themselves with a viscous matter consisting of air-bells, resembling saliva.

**Action on Plants.**—" Lysols " are poisonous to plants, but they are less irritant and caustic than carbolic acid. When absorbed by the roots they are as injurious to plants as carbolic acid. Otto showed that young maize and pea plants, raised in a nutritive media, suffered much if the latter contained 0·011 per cent. of " lysol," and died if they contained 0·025 per cent. The nutritive medium in these experiments remained neutral, or slightly acid. Trials on large scale show that " lysol " used in 5 per cent. solution to water soil before planting hindered the growth of the plant. A 1 per cent. " lysol " is injurious to seed potatoes of one and a half hours' steep. Solutions of " lysol "—even dilute—injure aerial parts of plants if a certain strength be exceeded, which varies with the sensitiveness of the plant from 0·4—3 per cent. The most delicate plants support 4 per cent. spraying; rose buds are injured by spraying with 1 per cent. solutions of " lysol " and the leaves with 2 per cent. solutions; the shoots of the apple-tree are burned and the apples spotted by a 2 per cent. solution. Fleischer has published the following table :—

TABLE LXXX.—*Showing the Action of " Lysol " Solutions of Various Strengths on the Organs of Different Plants.*

| Trees. | Organs. | 0·25 per cent. | 0·5 per cent. | 1 per cent. | 3 per cent. |
|---|---|---|---|---|---|
| Apple | Young shoots and leaves | Almost intact | Almost intact | Attacked | Burnt |
| Rose | ,, ,, ,, | Intact | Attacked | Far gone | ,, |
| Vine | Young shoots | Almost intact | Much attacked | Burnt | ,, |
| ,, | Adult leaves | Intact | Intact | ,, | ,, |
| Nasturtium | Young ,, | ,, | ,, | Attacked | ,, |

**Action on Fungi.**—The poisonous action of " lysol " on the spores of parasitic fungi is not yet well determined. A 0·5 per cent. solution prevents the germination of the spores of black rot (Ravaz and Gouirand). It is much inferior to cupric and mercuric salts.

**Action on Insects.**—Perroncito found that a 1—5 per cent. solution acts better on the eggs of the mulberry bombyx than a solution of corrosive sublimate of 0·5 per cent. Its energy is due to its soapy nature, which surrounds the insects and their larvæ and thus brings the insecticide in direct contact with the vulnerable parts of the insect. Insects generally succumb to a larger dose than that which is injurious to plants; thus the caterpillars of the cochylis touched by a 6 per cent. solution do not die. Fleischer has summed up in the following table his researches on the action of " lysol " on plant lice :—

TABLE LXXXI.—*Showing the Action of "Lysol" Solutions of Various Strengths on Plant-lice.*

| | Concentration of "lysol" solutions. | | | |
|---|---|---|---|---|
| | 0·25 per cent. | 0·5 per cent. | 1 per cent. | 3 per cent. |
| Woolly aphis treated individually . . . . | Disturbed | Killed | Killed | Killed |
| Woolly aphis in colonies dipped in solution . . . | Few attacked | Partly killed | All killed | All killed |
| Green aphis (willow) treated individually . . . | Killed | Killed | Killed | Killed |
| Green aphis in colonies dipped in solution . . . | All killed | All killed | All killed | All killed |

This table shows that a solution of "lysol" of 0·5 per cent. kills plant lice. "Lysol" is regarded by Fleischer as the best insecticide, and by Sturgis as greatly inferior to emerald green (Paris green).

**Use.**—*Sphærotheca pannosa*, Wallr. (blight of the peach and the rose-tree).—According to Schiller, Lambert, and Grübe, a solution of "lysol" of 0·5—1 per cent. kills this blight. Constantin and Dufour advise "lysol" for the same purpose. The dose must be varied with the delicacy of the rose or peach-tree. Ch. Charpentier circumscribes the disease by spraying every eight days, and immediately the disease appears with a solution of 3·5—4 per cent. "lysol." All the trees were not radically cured by this treatment, but the disease did not increase, and is not conveyed to the neighbouring sound trees.

*Peronospora viticola*, de By. (mildew of the vine).—Opinions are much divided as to the efficiency of "lysol" against mildew. In a report of the Wadenswiel Station, Switzerland, "lysol" is declared incapable of overcoming this parasite. Dufour also regards it as inefficient; it gave no result; its adherence to the leaves was also defective. "Lysol" is regarded in Switzerland as inefficient and is not used. Sipiere, on the other hand, advises its use in place of copper bouillies, and he has praised its good effects. A "lysolage" with a solution of 0·5 per cent. gave him the same results as Bordeaux bouillie, whilst it was also cheaper. This treatment had also the advantage of overcoming oidium and injurious insects. The first spraying was made with a solution of 0·5 per cent., from 20—30 April. The second with 0·7 per cent. solution from 1—8 May. The third with 0·1 per cent. solution from 1—8 June. Solutions of 0·5 per cent. are very injurious to young shoots, and 1 per cent. solutions burn them; but adult leaves stand these strengths better and are not burned, except by those above 2 per cent. To increase the adherence of this product it has been advised to make a bouillie of 1 lb. of "lysol," 2—3 lb. of plaster, and ¼ lb. of silicate of soda of 33° Bé., in 10 gallons of water.

*Phytophthora infestans*, de By. (potato disease).—Sturgis declares after experiments to disinfect potatoes with "lysol" that it cannot replace corrosive sublimate. "Lysol" in 1 per cent. solution injures potatoes in one and a half hours' steep. Its action on the spores is *nil*.

*Fusarium*.—Mangin advises against fusarium to disinfect the soil with "lysol" in place of corrosive sublimate.

*Guignardia Bidwelli*, Viala et Ravez (black rot of the vine).—Fernbach has studied the action of "lysol" on black rot. He records the good condition of a vine coated in winter with a 3 per cent. "lysol" solution and twice sprayed (1) with a 0·5 per cent. solution at the beginning of vegetation, (2) with a 0·7 per cent. solution at the end of May. Black-rotted leaves steeped in a 1 per cent. solution for five minutes, then washed and put in contact with a healthy leaf, no longer conveyed the disease to the latter. It was the same with black-rotted leaves placed in contact with a healthy leaf previously sprayed with a 1 per cent. preventive solution. Spraying and powdering done from bottom to top, so as to reach the lower face of the leaves on which the parasites preferably develop, arrest the disease in its evolution. Dieulafe advises to overcome black rot: (1) The spraying of the stems, the runners, and the pruning wounds with a solution of 2·5 per cent. of "lysol," done in winter at the time of pruning. (2) Spraying at the time of coming out in leaf of the buds with a solution of 0·5—1·0 per cent. (3) Dusting from April to August in moist weather with "lysol" powder.

*Mycogone perniciosa* (mole disease of the mushroom).—Constantine and Dufour recommend "lysol" in 2 per cent. solution for the disinfection of the frames. The process which consists in disinfection of the whole frame, as much of the soil as of its sides, gives better results than treatment with blue vitriol, boric acid, or bisulphite of lime and sulphurous acid. It prevents or overcomes other diseases of the mushroom such as the plaster (*Monilia fumicola*), gout (bacterian disease), etc.

*Nectria ditissima*, Tul. (canker of fruit trees).—Schiller remarks that canker of fruit trees is cured quicker by "lysol" than by tar.

**Coating Trees in Winter against Insects.**—Mathieu instead of liming the trunks, coats them with a solution of ½ lb. "lysol" in 1 gallon of water.

*Charæas graminis* (antler moth or grass moth).—Reuter effectually destroyed the caterpillar of this noctua by watering the meadows with a 2 per cent solution of "lysol" when it begins its ravages. "Lysol" is regarded as less energetic against the caterpillars which live protected by webs, such as the *Hyponomeuta* of the apple-tree, *Lyda nemoralis*, cochylis, etc. Barbut, using a 10 per cent. solution, could only destroy 20 per cent. of the caterpillars of the cochylis and 26 per cent. of the caterpillars of the pyralis.

*Cheimatobia brumata* (winter moth, Evesham moth).—Kraft advises "lysol" as a very effective medium to overcome this butterfly.

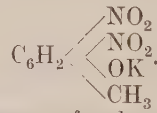
*Eurydema oleraceum*, L. (kitchen garden bug).—Lampa reports that after ten minutes these bugs are destroyed if the cabbages and beets are sprayed with a 2—4 per cent. solution of "lysol."

*Naked Plant-lice*.—Rossel recommends a 0·75 per cent. solution to destroy the rose aphis, a 1 per cent. solution to destroy that of the pear-tree and of the peach-tree. Kraf asserts that a 1 per cent. solution kills all naked lice. Fleischer found that a 0·25 per cent. solution even killed lice in tightly packed colonies. On the other hand, Otto commissioned by the "Lysol" factory itself to report on the efficiency of its product, reports the inefficiency of 0·25—0·5 per cent. solutions on lice at the same time as their injurious action on the plants. However, the lice die in twenty-four hours when touched by a 2 per cent. solution.

*Schizoneura lanigera*, Hausm. (woolly aphis).—“ Lysol ” destroys the woolly aphis, but, as Schöyen asserts, it is inferior to petroleum emulsions. Whilst Hotter regards its action as doubtful, Rossel found a 1 per cent. solution perfect. Fleischer regards “ lysol ” as active at 0·5; at 1 per cent. it destroys tightly packed agglomerations.

*Coccides.*—Hertzog recommends 2 per cent. “ lysol ” against the kermes of the rose laurel. Frank and Kruger assert that “ lysol ” solutions cannot kill coccides.

*Tetranychus telarius* (red spider).—This acarus may be got rid of by repeated spraying with 0·25—0·6 per cent. solutions (Rathay and Mussat). The browning of the leaves of the vine is overcome by spraying with 1 per cent. solution of “ lysol.” The acari of the genus *Eriophyes vitis* especially attack the young shoots in the spring which become atrophied. Muller recommends to cut the young shoots, destroy them, and coat the whole stem with 2 per cent. “ lysol.” *Thrips* does not resist any better.



$C_6H_2\begin{cases}NO_2\\NO_2\\OK\\CH_3\end{cases}$

**Potassium Dinitrocresylate,** $C_6H_2(NO_2)(NO_2)(OK)(CH_3)$.—**Preparation.**—Potassium dinitrocresylate is used in Germany for the preparation of a powerful insecticide known as antinonnine, because it is intended to destroy the caterpillar of the *Liparis monaca*[1] [the black arch-moth], called Nonne in Germany and in France. Potassium dinitrocresylate is probably the crude product of the nitration of sulpho-conjugated cresylol or xylene by the action of fuming nitric acid. Dinitrocresol is converted into a potash salt, soluble in water by potash lye.

**Properties.**—Antinonnine, discovered by Harz and Von Miller, is a mixture of equal parts of dinitrocresylate of potash and soap. It forms a white crystalline paste soluble in water.

**Action on Plants.**—A solution of antinonnine of 0·1—0·125 per cent. is without action on plants. When a stronger solution has to be used on the tender parts of plants, it suffices to follow up the treatment by washing twenty-four hours afterwards to prevent its action on the plant.

**Action on Insects.**—Antinonnine is poisonous to insects. A small dose suffices to kill them; it also acts on insects and soft-skinned larvæ; coccides, and certain carapaceous insects, such as weevils, resist it (Hollrung). It is very poisonous to caterpillars, the larvæ of the tenthredes (saw-flies), *Ptereneus ribesi*, Thorsen (gooseberry saw-fly), *Lophyrus rufus* (Schöyen), the thrips of grain crops, acari, plant lice (Taschenberg), in doses of 0·125 per cent. to 0·30 per cent.

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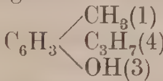
[1] LIPARIS MONACA (*Bombyx monaca*) (black arch moth or “ Nonne ”).—The female lays its eggs at the end of July in small heaps of 20—50, forming plates which are never covered with hair. They are hidden in the cracks of the bark near the ground; they pass the winter. Hatching occurs at the end of April; the caterpillars remain together five to six days forming what are called mirrors; they gnaw pine needles.

*Polyporus vaporarius*, *Polyporus destructor*, *Trametes cryptarum*, or *Polyporus pini*, Pers. (red rot of the pine).—Antinonnine has been found an excellent means of destroying these fungi. Dilute solutions, only containing 0·065 per cent. of antinonnine, still produce the desired effect.

*Liparis monaca*, L. (the black arch moth which attacks pines), (French and German syn. *Nonne*).—Antinonnine is regarded as a specific against the caterpillar of the *Nonne*. An antinonnine solution of 0·33 per cent. acts in a categoric manner after twelve to twenty-four hours; 66 per cent. of the caterpillars treated were killed after twenty-four hours. By increasing the dose of soap the action is intensified.

*Charæas graminis* (antler moth or grass moth).—Reuter reports the good effect of a solution of $\frac{1}{4}$ lb. antinonnine and $1\frac{1}{4}$ lb. soap in 10 gallons of water against the caterpillar of this noctua at the time when it appears in meadows.

*Mice and Rats.*—Antinonnine is a violent poison to rodents; 0·5 gramme kills a rabbit. For rats and mice a mixture is prepared of 10 parts of sausage grease and 1 part of sugared antinonnine. Mice die after having absorbed 0·001 gramme, and rats after ingestion of 0·02 gramme of antinonnine. It suffices to soak pieces of bread with a solution of sugared antinonnine, and to place it in winter in their holes.

**Thymol,**  $C_6H_3\left\langle\begin{matrix}CH_3(1)\\ C_3H_7(4)\\ OH(3)\end{matrix}\right.$.—**Preparation.**—Thymol is present in oil of thyme. To isolate it the oil of thyme is agitated in a strong solution of soda. The thymol is dissolved in the alkali. This liquid is separated by decantation from the supernatant cumene and thymene. The liquid obtained is diluted and saturated by hydrochloric acid which precipitates the thymol.

**Properties.**—In the pure state it forms colourless, crystalline lamellæ, with a sharp and peppery taste. It is but slightly soluble in water (1 in 1000), more readily soluble in alcohol and alkaline lyes. It precipitates albumen and possesses remarkable antiseptic properties.

*Hypomyces perniciosus*, Magnus (mole disease of the mushroom).—Constantin and Dufour recommend a solution of 0·25 per cent. to overcome the mole when the disease appears; it is necessary to remove all the horse dung, to disinfect the premises, and to plant afresh in new dung.

β-**Naphthol,** $C_{10}H_7{\cdot}OH$.—**Preparation.**—To obtain β-naphthol from naphthalene it is necessary first to prepare the sodium salt of β-naphthalene sulphonic acid. It is prepared by heating together equal parts of naphthalene and sulphuric acid at 200° C. The mixture is run into water. The liquid obtained is treated with lime, boiled, and filtered. The lime salt is converted into a soda salt by the addition of carbonate of soda, filtering, and evaporating the liquid to a suitable concentration. The crystals formed are separated from the mother liquor by centrifuging, and melted with 2 parts of caustic soda and the water required to fuse the mixture. The temperature is raised gradually to 300° C. When the reaction is finished the product is dissolved in water, hydrochloric acid added, and the precipitated β-naphthol collected on a filter.

**Properties.**—β-Naphthol crystallises in white lamellæ; it melts at 122° C., and boils at 286° C. It is but little soluble in water, but is soluble in alcohol and alkalies. It is antiseptic.

**Action on Plants.**—Soluble β-naphthol, in the form of its sodic salt, burns the leaves; the insoluble salts, on the other hand, such as those of copper, iron, and lime, are not poisonous to plants.

**Action on Fungi.**—According to Mangin a solution of naphtholate of soda, 1 in 10,000, kills the spores of *Bremia lactucæ* (lettuce mildew) and *Heterosporium echinulatum* (fairy ring of carnations), but it is without action on those of *Nectria cinnabarina* (coral spot disease), *Peronospora arborescens*, and *Uromyces aviculariæ*.

**Use.**—β-Naphthol is rarely used alone, but with soapy water, or in the form of a soluble salt.

β-*Naphtholate of Soda.*—144 grammes of β-naphthol are beaten up with hot water and caustic soda lye added to complete solution (100 grammes of caustic soda of 44° Bé.).

β-*Naphtholate of Lime.*—To ½ gallon of a 5 per cent. solution of naphtholate of soda ½ gallon of milk of lime is added, containing 1 lb. of lime. This bouillie is recommended by Mangin as a substitute for lime for coating fruit trees.

β-*Naphtholate of Copper.*—4 lb. of β-naphthol are dissolved in 3 gallons of hot water, containing 0·3 gallon of caustic soda of 36° Bé.; 2½ lb. of blue vitriol in 5 gallons of water are then added whilst stirring, and the whole made up to 100 gallons of bouillie. This contains naphtholate of copper, with great adherence, which does not injure the leaves.

β-*Naphtholate of Iron.*—This bouillie is made like the preceding, replacing the blue vitriol by 2·7 lb. of green vitriol.

*Peronospora viticola*, de By. (vine mildew).—Dufour tried naphtholate of soda against this disease without success. Mangin, however, recommends a solution of naphtholate of soda, to which a little potato starch [*farina*] has been added, so as to distinguish the spots treated. Naphtholate of copper would be equally fit to combat mildew. The soda bouillie decomposes on the leaves under the influence of the carbonic acid of the air into carbonate of soda and naphthol which is very adherent to the leaves and resists heavy rain.

*Gloeosporium macropus*, Sacc. (orchid mildew).—Mangin advises use of 2 per cent. naphthol; it prevents the germination of the spores.

*Poppy* [*Œillet*] *Disease.*—Mangin recommends to steep before transplanting the end of the slips in a solution of 15 lb. of naphthol and 45 lb. of soap in 100 gallons of water or 5 oz. of naphtholate of soda in 62½ gallons of water (5 grammes in 10 litres).

*Fusarium roseum.*—Mangin advises the disinfection of the soil by a solution of naphthol 1—2400. This method is disputed by Delacroix. Sacardo advises with the same object a solution of 0·5 per cent. of naphtholate of soda against rust of poppies [Œillet], rose-bushes, asparagus, etc.

**Methyl Violet or Pyoctanine.**—Pyoctanine is a methylated or ethylated rosaniline obtained either by heating rosanilines to about 140° C. with methyl or ethyl chlorides or iodides dissolved in alcohol, or by treating dimethylaniline by carbon oxichloride in presence of aluminium chloride (yellow pyoctanine is a hexamethylated auramine).

**Properties.**—Methylated and ethylated rosanilines in the form of salts constitute crystallized violet colouring principles soluble in water. They are used to make aniline inks, and in the dyeing of fabrics. Pfeiffer determined the injurious action of pyoctanines on phanerogams. Kreminski, and especially Stilling and Wortmann, have examined the antiseptic action of pyoctanines. They have shown that it suffices to sterilize a medium, such as meat juice, for it to contain 0·005 per cent. of methyl violet, or 0·5 per cent. of yellow pyoctanine. The *Staphylococcus pyogenes aureus* does not develop in a solution of 1 in 2,000,000 of methyl violet. The *Penicillium glaucum* does not develop in a medium drenched with a solution of 1 in 10,000 of pyoctanine violet. The pyoctanines do not coagulate albumens, like powerful antiseptics such as corrosive sublimate, formol, etc., but albumenized bodies have a certain affinity for these products and eliminate them from water whilst becoming dyed. The colour concentrates itself there, and if the amount absorbed is sufficient the corpuscles are arrested in their evolution, the dyed bacteria give up their colour to pure water, and they can become completely decolorized and regain by this fact their primitive vitality if the surrounding water is in sufficient quantity to extract the colour simply dissolved in their plasma.

**Use.**—*Acrostalagmus albus.*[1]—Stilling found that it sufficed to water the infected dung or the dunged borders with a dilute solution of methyl violet to stop the development of this fungus.

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[1] ACROSTALAGMUS ALBUS.—Fungus which covers with a white thick down farmyard dung fermented at too great a heat. It may become injurious to young cultivated plants.

# CHAPTER XXIV

## CARBON COMPOUNDS (*continued*)—NICOTINE TOBACCO JUICE—QUASSIA —HELLEBORE—PYRETHRA—DELPHINIUM (LARKSPUR)—DERRIS ROOT—STRYCHNINE—NUX VOMICA—WALNUT LEAVES—GLUE—CUTCH—ALOES.

**Nicotine.**—Tobacco is furnished by plants originally natives of tropical America now acclimatized in many countries, chiefly *Nicotania tabacum* and *Nicotania rustica*, L. When ripe the leaves of these plants are collected and dried in drying machines. The green leaves contain 1·5—9 per cent. of nicotine, the dry leaves up to 4 per cent.

Tobacco powder [? snuff] is made from greasy tobaccos. The leaves are moistened with salt water, then cut into thongs and laid in heaps of about 40 tons. Fermentation sets in; after four months the tobacco is conveyed to mills. It is moistened again and piled up to undergo a second fermentation which lasts eleven months. Tobacco juice is obtained in the tobacco manufactories by treating the coarsely divided leaves with boiling water. The liquor obtained is filtered and evaporated to the right strength, then the substances injurious to plants are removed. In France the culture, manufacture, and sale of tobacco are the subject of a monopoly exploited by the State. The Minister of Agriculture publishes special sheets of information sent to the Mairies (Town Halls), giving the price and the strength in nicotine of the juice sold by this administration. The old juices are differentiated from the new or rich juices; the latter are five to six times stronger than the former. The French tobacco administration delivers the latter with up to about 10 per cent. of nicotine. They are sold to the public in tins in the tobacco markets and in warehouses. Tobacco juice enters into many insecticides to strengthen their action. A few examples only will be quoted. To impart adherence to these insecticides gum-arabic, sugar, etc., is added.

**Insecticides with a Tobacco Basis.**—(1) 5 lb. tobacco juice, 1 lb. soft soap, in 100 gallons of water. (2) Dissolve 4 lb. soft soap in 10 gallons of water, then add, whilst constantly stirring, 6 lb. of tobacco juice, 5 lb. of amyl alcohol, and 20 lb. of ordinary alcohol. (3) Dissolve 2½ lb. of soap in 2 gallons of hot water, add 1½ lb. of amyl alcohol. Run into this liquor a decoction of 3 lb. of tobacco juice in 8 gallons of water. (4) Water 100 gallons, rich juice, 10 per cent, 1 gallon, soft soap 10 lb., commercial carbonate of soda in crystals 2 lb., methyl alcohol 1 gallon. The soap increases its adherence and the wood spirit appreciable increases the action on certain parasites. (Note of the French Ministry of Finance regarding tobacco juice drawn from the National factories for the destruction of insects.) (5) Add to a 2 per cent. tobacco juice a little carbolic acid. (6) Add to 4 lb. of the above carbolized tobacco juice 1½ lb. of creoline, 1 lb. of soft soap dissolved in 10 gallons of water. (7) Dissolve 3 lb. of soft soap, in 5 gallons of water, add thereto a solution of 2½ lb. of blue vitriol, neutralize by 11 lb. of caustic potash. After stirring well run in 5½ lb. of tobacco juice and 2½ lb. of "creoline."

**Properties.**—Tobacco juice is characterized by a special alkaloid nicotine. Pure nicotine is an oily liquid, colourless, soluble in water, alcohol, and fatty oils; it precipitates almost all metals from solutions of their salts; with copper it yields a green precipitate soluble in a large excess of nicotine. Nicotine is a violent poison to mammals. A single drop of nicotine suffices to kill a dog. It causes giddiness, abdominal pains, followed by death in a few minutes.

In view of the possibility of using tobacco dust as a source of nicotine in combined lime-sulphur and lead arsenate sprays, experiments were made in the U.S.A. to determine the amount of nicotine dissolved from fine ground tobacco dust by lime-sulphur. Tobacco dust containing 1·2 per cent. of nicotine was added at the rate of 200 lb. to 100 U.S. gallons of concentrated lime-sulphur. The results show that there is little difference in the solvent action of water and lime-sulphur, and that heating does not increase the quantity of nicotine found in solution. The addition of an alkaline substance such as hydrated lime does not increase the solvent power of water or, probably, of lime-sulphur. The combination of tobacco dust and lime-sulphur may, however, liberate hydrogen-sulphide, and this may be avoided by the addition of a few pounds of hydrated lime per 100 gallons of spray mixture.

**Action on Plants.**—Tobacco juice is used as an insecticide in 1 per cent. doses, say 0·1 per cent. of nicotine. It injures plants; mixtures with soap still further increase its injurious action. To obviate this drawback it is necessary to follow the sprayings by careful washing after one hour's interval. Fumigations in greenhouses are less to be feared for the plants; however, Decaisne has observed that certain cold-house orchids stand this treatment badly.

**Action on Insects.**—Nicotine is a violent poison for most insects and their larvæ. Chittenden observed that it did not act so on all insects. A solution of 0·1 per cent. (1 per cent. of the rich juice of the French manufactories), especially if it contains 1 per cent. of soap, forms an energetic liquid against the most diverse insects. If the published results do not always agree that is due to the different nicotine content of the juices tested on the same insects. It is agreed that nicotine solutions have a specific action on the caterpillars of butterflies, the false caterpillars of the saw-flies, on non-protected lice, thrips, and acari. In closed spaces the action of the vapours of nicotine is drastic even on coccids.

**Use.**—In enclosed spaces, greenhouses, or spaces covered in for the purpose, the following process is used to obtain entire disinfection of the plants therein :—

**Fumigation or Evaporation of Nicotine in a Closed Space.**—It is carried out in different ways : (1) Tobacco is laid in a special apparatus outside the greenhouse above red-hot coals, the combustion of which is accelerated by a bellows. A pipe leads the vapours charged with nicotine inside the enclosed space. (2) Moisten tobacco leaves and place them on the hot pipes of the hothouse. The water evaporated carries sufficient nicotine to kill the insects. (3) Slow evaporation inside the greenhouse of tobacco juice placed on small stoves. (4) Projection of tobacco juice on strongly heated bricks or irons.

**Use in Open air.**—Open-air plants infested by insects are sprayed with tobacco juice diluted with water to contain 1 per cent. of rich juice. Nicotine solutions not moistening sufficiently the insects touched it is better to use soapy bouillies which adhere and moisten much better and thus act more quickly. After one hour the insects touched are dead; the plants treated must then be washed to prevent the deadly action of the nicotine and the soap on the plant.

Tobacco powder spread by the bellows on the insects is very efficient, and in many cases it is more active than pyrethra powder.

Nicotine insecticides have been more generally and extensively developed than perhaps any other class in the period since this book was first issued. In a British Government leaflet Mr. A. H. Lees, M.A., points out that for the purpose of destroying the sucking class of insect pests, such as aphis, red spider, apple sucker and capsid bug, it is necessary to use a contact wash. Contact washes usually contain soap in order to give a certain amount of wetting power to the fluid. In the author's view, the most satisfactory agent is a 2 per cent. paraffin emulsion. Of the many possible emulsions of paraffin and soap this gave the maximum of wetting power with the least amounts of soap and paraffin, and the least tendency to burn. Used alone, this emulsion is capable of killing aphis and a good many, if not all, suckers. It penetrates flower trusses of the apple, even if infested with suckers, and will wet leaves spun together by winter moth caterpillar if there is any way at all into the mass. It is, by itself, a fairly good contact insecticide. It is not, however, potent enough to kill capsids, caterpillars or beetles. Nevertheless, if ½ of 1 per cent. of nicotine is added to it its power is greatly increased. The formula of the spray fluid is as follows: Soft soap, 20 lb.; paraffin, 2 gallons; nicotine, ½ lb.; water, 100 gallons. For use, dissolve the soft soap in 5 to 10 gallons of boiling water. Emulsify the paraffin in the hot soft-soap solution by taking up the paraffin in a garden syringe with a rose attached, a syringeful at a time, and squirting it violently into the soap solution. Add the nicotine, and dilute to 100 gallons (*i.e.*, adding 90 to 95 gallons as required). For a 40-gallon paraffin barrel the formula is: Soft soap, 8 lb.; paraffin, 6½ pints; nicotine, 3 oz.; water, 40 gallons. Stir the mixture well before use. This mixture has been tried on the small scale against various insects, and has proved successful. It has recently been shown that though nicotine itself is safe to use on fruit that will shortly be eaten, since it is extremely volatile, nicotine sulphate is not. This salt of nicotine is not volatile, and therefore remains on the fruit for a considerable time. If the above mixture is used on gooseberries the grower should be sure that he is using nicotine and not nicotine sulphate; this warning should also be observed by the dealer who supplies the ingredients.

In some American experiments with various types of tobacco with a high nicotine content for insecticidal purposes, *Nicotiana rustica* alone gave satisfactory results. Plants that had been topped or had had the suckers removed during growth gave a very much higher percentage of nicotine. While nicotine can readily be extracted from tobacco wastes by steeping the material in cold water, it can be obtained even more readily by treating the tobacco with cold water, bringing it to the boil and immediately filtering through cheesecloth, a very few washings with hot water freeing the residue of nicotine. Solutions of nicotine thus obtained of 0·06 to 0·2 per cent. strength, mixed with a little soap, possess aphicidal properties comparable with those of nicotine solutions of the same concentration made by diluting a standard 40 per cent. nicotine solution.

A very important advance in the use of nicotine preparations was the introduction in 1917 of so-called nicotine dusts. These dusts consist of a finely-powdered inorganic carrier, kaolin being the material first employed, with which is incorporated nicotine sulphate or free nicotine solution. Kaolin was found to be objectionable in that it adsorbed and held back too much of the nicotine. Various other carriers were tried, among them hydrated lime, quicklime, refuse sugar-beet lime, powdered calcium and magnesium carbonate, finely ground sulphur, gypsum, talc, and diatomaceous earth. These were found to vary in effectiveness, but the reasons were not understood, and it soon became evident that there were a number of factors in connection with the preparation and use of these materials which must be investigated before they could become a commercial success. The dust that volatilizes the largest percentage of its nicotine content within a certain time is the most effective as an insecticide. Extensive work has been done by Headlee and Rudolphs on the effect of the chemical and physical nature of the carrier, the influence of alkalinity, moisture, and temperature on the rate of evolution of the nicotine and on the relation of the killing power to the rate and extent of the liberation of the nicotine when applied to the plants. They state that for carriers impregnated with nicotine sulphate the evolution of nicotine is mainly dependent upon chemical reactions (decomposition of the nicotine sulphate), but that physical factors, such as surface tension, are involved also, and in the case of dusts with free nicotine only physical factors are involved. They recommend magnesium limestone (dolomite) and hydrated lime containing 10 to 30 per cent. of dolomite as effective carriers for nicotine sulphate.

Practically the same conclusions are reached by Thatcher and Streeter. They divide the materials that may be used commercially as carriers for solutions of nicotine sulphate into three groups: "adsorbent" substances such as kaolin, kieselguhr, and talc, which tend to prevent volatilization; "inert" substances which have no effect other than the exposure of large surfaces to evaporation; and "active" substances, which increase the volatility of the nicotine by changing the sulphate into a more volatile form, such as hydrate and carbonate of lime. Carriers for solutions of free nicotine they divide into two groups, "adsorbent" and "inert," the latter being the more desirable for the preparation of active dusts. They stress the importance of the presence of water, stating that some free water is necessary in the case of nicotine sulphate dusts to permit the reaction by which nicotine is liberated, but that water in excess of this amount is objectionable in that the volatility of the nicotine is decreased owing to its solution in the surplus water. Some work on the loss of nicotine from nicotine dusts during storage is included. De Ong concludes, as a result of his work on the relation between the volatility and toxicity of nicotine in sprays and dusts, that " the volatilization curve of nicotine is almost an exact parallel of the curve of toxicity both of fumigation and spraying. Dust carriers follow this same law." An investigation of the rate of loss of nicotine from nicotine dusts (prepared from nicotine sulphate and free nicotine solutions with various carriers and packed in different types of containers) has recently been completed by McDonnell and Young. The products were stored for periods ranging from one to two years, and analyses were made at intervals. The result showed that: (1) the loss of nicotine from dusts containing nicotine sulphate was in the following order, beginning with the lowest: kaolin, kieselguhr, talc, calcium sulphate (gypsum), calcium hydrate, and calcium carbonate; (2) dusts made up with free nicotine solution lost nicotine more rapidly than those containing nicotine sulphate, but the effects of the carriers were in about the same order; and (3) canvas bags, pasteboard boxes and paraffined boxes are unsatisfactory containers for nicotine dust preparations and should not be used. Air-tight metal or glass containers only should be employed for the commercial packing of these materials.

The formulas given below are typical of nicotine dust used against truck-crop insects in the U.S.A.

### Formula No. 1.

Four per cent. nicotine sulphate, equivalent to 1·6 per cent. nicotine.

| 100-*pound lots.* | | | 12½-*pound lots.* | | |
|---|---|---|---|---|---|
| Kaolin | pounds | 72 | Kaolin | pounds | 9 |
| Hydrated lime | do | 24 | Hydrated lime | do | 9 |
| Nicotine sulphate | do | 4 | Nicotine sulphate | ounces | 8 |

### Formula No. 2.

Five per cent. nicotine sulphate, equivalent to 2 per cent. nicotine.

| 100-*pound lots.* | | | 12½-*pound lots.* | | |
|---|---|---|---|---|---|
| Hydrated lime | pounds | 95 | Hydrated lime | pounds | 12 |
| Nicotine sulphate | do | 5 | Nicotine sulphate | ounces | 10 |

### Formula No. 3.

Six per cent. nicotine sulphate, equivalent to 2·4 per cent. nicotine.

| 100-*pound lots.* | | | 12½-*pound lots.* | | |
|---|---|---|---|---|---|
| Hydrated lime | pounds | 54 | Hydrated lime | pounds | 6¾ |
| Finely-ground sulphur | do | 40 | Finely-ground sulphur | do | 5 |
| Nicotine sulphate | do | 6 | Nicotine sulphate | ounces | 12 |

In the preparation of this dust it is very important that the nicotine sulphate be thoroughly mixed with the carrier. This can be accomplished by first mixing and sifting the materials composing the carrier, then combining the required amount of nictorine sulphate with the dust, adding the nicotine slowly and mixing all thoroughly. The nicotine sulphate can be added to the dust by the use of any convenient sprinkler. A pint fruit jar with a metal top from which the porcelain has been removed, punched with holes by the use of a 6-penny nail, makes a good sprinkler. After the addition of the nicotine sulphate the mixture should be run through a fine sieve, 20 meshes to the inch, with the aid of a brush. This last operation should be repeated at least three times. Be sure that all the material is worked through the sieve, since if this be neglected a large quantity of the nicotine may be lost. Powdery mildew is a common disease of peas which is most successfully combated with sulphur. The use of a nicotine-sulphur dust, in which the carrier is about 70 per cent. finely ground sulphur, will control not only the mildew but also the pea aphis. In parts of southern California peas are damaged by the beet army worm and by cutworms. These may be combated, especially when the insects are young, by including in the mixture 10 per cent. of powdered arsenate of lead. On cabbage, the nicotine dust will kill the aphis and also some cabbage worms, but if the latter are numerous, the nicotine-arsenate of lead combination may be used. This is also effective against flea-beetles on tomatoes, cucumber beetles, melon aphis and onion thrips. Nicotine-sulphur dust should be used cautiously on cucumbers or melons, as more or less burning of the foliage may result, especially in very hot weather. This dust is partially effective against the red spider and is effective against mildew.

The concentration chosen for some American tests on the commercial nicotine soaps, both oleate and a coconut oil-fatty acid compound, was 1 part in 500, using soft water. The nicotine soap solutions were compared for wetting power and effectiveness on green apple aphis (*Aphis pomi*) on young apple trees and current bushes; woolly aphis (*Schizoneura lanigera*) on twigs of apple trees; and cabbage aphis (*Aphis brassicæ*) on turnips and cauliflower. An effective spraying solution for killing the woolly aphis (American blight) consists of a mixture of 10 gallons of rain water, 6½ oz. of carbonate of potash, 4 lb. of sulphoricinate of soda, 2 lb. of methylated spirit, and 1 lb. of strong extract of tobacco (10 per cent.). Both nicotine soap solutions (whose concentration of nicotine was practically 0·05 per cent.) were found to be very effective in killing the aphis, provided the spraying was done with sufficient thoroughness to reach and wet all the insects on the affected plants. The superior wetting and spreading power of the nicotine-coconut oil-fatty acid compound was particularly noticeable on the waxy leaves of the turnips and cauliflowers, and on the downy young leaves of the apple. Since nicotine volatilises more or less rapidly from many of the commercial preparations containing it, experiments have been made in the U.S.A. to determine whether shortage of it was due to volatilisation or decomposition or to the fact that the amount of nicotine claimed had never been present. A number of soaps were prepared by different formulæ, and packed in various containers. The results showed that hard soaps, made from sodium hydroxide, menhaden fish-oil and free nicotine solution, lost nicotine rapidly on storage regardless of the type of package. Potash soaps (soft soap) and soft soda soaps containing nicotine retained practically their original nicotine content for a period of four years. The indications are that the change in the nicotine depends on the physical condition of the soap and not on excess of alkali, the kind of alkali, the use of heat in the preparation of the mixture, or on the type of package. The decrease in nicotine content in the hard soaps was obviously not due to loss of nicotine by volatilisation but to chemical changes by which it was converted apparently into insoluble polymeric form, or a condensation product. The fact that the decrease in nicotine was accompanied by a decrease in the fatty acids of the soap is an indication that there is probably some reaction between the two. Stable fish-oil soap nicotine preparations can therefore be made, though apparently not in cake form. The cake form is more satisfactory for packing and transport, but on the other hand the soft soap will dissolve in water much more readily and is therefore more desirable for the consumer. Experiments are now being made to determine whether or not soaps made from fats and oils other than fish-oil with which nicotine is incorporated will behave in the same manner, and also to obtain more information with respect to the composition of the resinous material formed.

The British Ministry of Agriculture formula for a nicotine soap-wash for fruit trees against leaf-eating pests (caterpillars, aphides, etc.) is: Nicotine (98—99 per cent.) ¾ oz., soap (soft) ½ lb., water (soft) 10 gallons. If the water is hard, 1 lb. of soap should be used. The soap is dissolved in hot water and diluted to the required strength, after which the nicotine is stirred in. Nicotine is poisonous and should not be used near vegetables or green fruit, unless these are to be left ungathered for a fortnight. Against apple capsids the proportions recommended are: nicotine 3 oz., soft soap 4 lb., water 40 gallons.

Nicotine insecticides are recommended by the British Ministry of Agriculture for spraying against cherry black-fly (*Myzus cerasi*).

A nicotine sulphate dust, containing 5 per cent. of nicotine sulphate (40 per cent. black leaf) equivalent to 2 per cent. of pure nicotine has been used with good effect against aphides (*Macrosiphum persicæ*) infesting seed potatoes.

For destroying black currant mite (*Eriophyes ribi*, Nalepa) causing "big bud" the proportions should be nicotine, ½ oz., soft soap 4 oz., water, 5 gallons.

Against the apple red bug [*Heterocordylus malinus*] in Pennsylvania nicotine dust proved as satisfactory for use on the petals as nicotine spray. Two per cent. nicotine sulphate with dolomite or hydrated lime as a carrier was used with success.

Against the green apple bug [*Lygus communis* var. *novascotiensis*], in Nova Scotia good results were obtained by using a dust of 4·7 per cent. nicotine sulphate, 75·3 per cent. hydrated lime and 20 per cent. pulverised quicklime.

Nicotine dust proved unsatisfactory in Ontario as an ovicide against the eggs of the grape leafhopper, *Erythroneura comes*, but the addition of lime apparently increased its effectiveness. Nicotine sulphate 1 : 1200 with 5 lb. of hydrated lime in 40 gallons destroys all eggs in all stages of development.

Against the Criocerid, *Lema tristis*, Hrbst. (*flavipes*, Suffr.), in France, in cases of severe infestation, Bordeaux mixture with nicotine, or a solution containing 1·5 per cent. of soft soap and 0·15 per cent. of pure nicotine, using about 50 to 60 gallons per acre, is advocated.

A French formula recommended against Aphids attacking fruit-trees is 1 lb. of nicotine extract (at 5 lb. per gallon strength) with 5 lb. of soap in 50 gallons of water. This formula is not injurious to syrphids and coccinellids, which devour many of the aphids Equally good results are obtained with 5 per cent. pyrethrum powder mixed with a 2 per cent. solution of soap in ordinary or, if possible, rain water. In 3 days this mixture is ready for use, and must be diluted with an equal amount of water. This will keep for some time, and is cheaper than the nicotine solution, provided that the pyrethrum is home-grown.

The spray recommended for a control of *Thrips tabaci* consists of about 1 U.S. pint of nicotine (40 per cent.) to 100 U.S. gallons of water and 4 lb. of laundry soap. Two applications should be made with an interval of six or seven days. If a dust is applied, one of the standard nicotine dusts should be used.

In an outbreak of springtails *Smynthurus hortensis*, Fitch, on onions in Massachusetts in 1922, nicotine dust (2 or 4 per cent.) was found to kill all the insects, all except the largest being killed almost as soon as the dust touched them.

Experiments for the control of *Myzus ribis*, L., on currants have been continued for several years in the U.S.A. The mixtures used depended on nicotine as the killing agent. This was derived from superfine tobacco dusts, containing 1 and 3·5 per cent. nicotine respectively, or nicotine sulphate (40 per cent. nicotine). Dust mixtures were applied with a power dusting machine, approximately at the rate of 1 lb. per bush, and sprays with a power spraying outfit, at an average rate of about 2 U.S. gallons per bush. One application was made after the aphids had hatched from the winter eggs, usually when the more advanced leaves had a diameter of one-half to one inch, with subsequent applications whenever the aphids appeared to be developing in destructive numbers. It was generally found necessary to make a second application after blossoming, and in some cases a third when the berries turned red. The best results were obtained with soap and nicotine sprays at standard strength and sulphur lead arsenate dusts containing 1 and 2 per cent. of nicotine. The spray formula recommended is 1 U.S. pint of nicotine sulphate, 5 lb. of soap and 100 U.S. gallons of water. For the preparation of home-made dusts containing nicotine sulphate, hydrated lime or superfine dusting sulphur should be used as the carrier. The sulphur will also control leaf spot, but though generally safe, it caused injury to foliage in some cases. Dusting should be done so far as possible on still days when temperatures are high and there is as little moisture as possible on the foliage.

*Haltica ampelophagus*, Guer. (altise of the vine).—In the opinion of d'Aurelles de Paladines tobacco juice of 3° Bé. black snuff mixed at the rate of 12—15 per cent. with Apt sulphur, a mixture of 1 per cent. of rich juice, 1 per cent. of petroleum, and 1 per cent. of soap forms an insecticide which destroys the altise of the vine. Von Schilling regards tobacco infusion as the most efficient medium against the altise if the spraying be renewed after each rain. Thiele observes that these preparations have no action on the altise unless the insects are touched by the liquid; the insecticide coatings which cover the leaves after treatment do not remove the altise, hence the necessity of multiplying the treatments to obtain a favourable result.

*Altise of the Gardens.*—When young plants commence to shoot up they are copiously watered and then wood sawdust strongly soaked in dilute tobacco juice is spread over the whole of the seedlings.

*Crioceris asparagi*,[1] L. (the asparagus beetle).—Blin recommends as very energetic a mixture of 10 lb. of tobacco juice infused in 30 gallons of boiling water, and 2½ lb. of soft soap; 66 gallons of this mixture suffice for 2000 asparagus plants. This treatment completely destroys the larvæ.

*Crioceris melanopa*, L. (crioceris of cereals).—Sajo recommends tobacco juice, used as spray on infested fields. The following are the results of a trial made with a solution of 20 lb. of tobacco juice, testing 14·5 per cent of nicotine in 10·6 gallons of water.

TABLE LXXXII.—*Action of Tobacco Juice on Crioceris of Cereals.*

| | Barley in lb. |
|---|---|
| Plot treated with 154 gallons of this solution . . | 199 |
| Untreated plot . . . . . . . . | 78·1 |
| Immune plot . . . . . . . . | 215·6 |

There is no doubt of the good effect of this treatment. The operation is best done at the moment the larvæ are hatched. At that time the field is sprayed in the direction of its width, then it is sprayed in the direction of its length.

*Rhynchites fragariæ.*—This insect which cuts the strawberry leaves is overcome by tobacco juice (0·5 Bé.), (Ernest).

*Zabrus gibbus* (*carabe bossu*), (cereal zabrus).—Three per cent. of Hungarian tobacco extract in 100 litres of water are perfectly capable, according to Sajo and Naszay, of destroying this insect and its larvæ in wheat fields. The treatment is applied in the month of April; the stimulating effect is at once seen in the improvement in the growth of the plant.

*Cassida viridis* (artichoke tortoise beetle).—Its larva gnaws the leaves of the artichoke. Debray destroys it by tobacco infusion.

*Sitones lineatus*, L. (the striped pea weevil).—Noel advises tobacco juice 0·5° Bé., and containing 1 per cent. of soft soap.

*Ocneria dispar* (bombyx dispar, gipsy moth)—Berlèse destroyed in five days 100 per cent. of the caterpillars of this butterfly with a 5 per cent. juice; with a 2 per cent. carbolized juice he only killed 80 per cent. of the caterpillars.

*Abraxas grossulariata*, L. (magpie moth).—Soapy solutions of tobacco juice free gooseberry bushes from the caterpillars of the magpie moth.

*Cochylis ambiguella*, Hubn. (cochylis of the vine).—Nessler's insecticide with a tobacco basis (formula No. 3) is perfect to destroy the caterpillar of the cochylis. Zechini and Silva advise for the same purpose their insecticide (formula No. 6). Jemina proposes his insecticide (formula No. 7) to overcome simultaneously both the cochylis and mildew.

*Cydia* (*Laspeyresia*) *molesta* (Busck). The Oriental peach moth.

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[1] CRIOCERIS MELANOPA (grain crioceris).—This small (4½ millimetres) coleoptera is bluish; it and also its larvæ gnaw the epidermis of herbs and cereals.

A combination spray of nicotine, 1–800, added to fungicidal-lead arsenate (1 lb. to 50 U.S. gals.) on a 14- or 7-day schedule resulted in an increase of peaches free from this pest amounting to 13·3 per cent.

*Hyponomeuta malinella*, Zell. (small ermine moth of apple-tree).—Sonnino praises 2 per cent. carbolized tobacco juice.

*Pentatoma* (*Carpocoris*) *baccarum*,[1] L. (bug injurious to fruit trees).—Taschenberg recommends to spread moist cloths in front of the fruit walls, and to fumigate with tobacco between these and the walls as is done in greenhouses.

*Eriocampa adumbrata* (slimy caterpillar, slug-worm).—Bach records the good effects of tobacco powder spread on the larvæ. Tobacco juice at the rate of 2 lb. of juice, with 14·5 per cent. of nicotine in 10 gallons of water is regarded by Sajo and Czerhati as an excellent method of destroying the slug-worm.

*Ptereneus ventricosus*, Kl.; *Emphytus grossulariæ*, Fb. (gooseberry and currant saw-fly).—To get quit of this insect Ahlisch advises spraying with a liquor consisting of 2½ gallons of tobacco juice, 5 lb. of soft soap, and 40 gallons of water.

*Lophyrus pini* (the pine saw-fly).—Sajo advises to destroy the larva of the pine saw-fly by spraying with a solution of 2 lb. of tobacco juice containing 14·5 per cent. of nicotine in 10 gallons of water.

*Diplosis rosiperda*.—This rose cecidomia[2] (fly), the larvæ of which is in the rose shoots, is fought in greenhouses by fumigation with tobacco.

*Eurhinocola eucalypti*, Mask.—Remedial measures include spraying with a wash of ⅓ oz. of nicotine (98 per cent.) and 6½ oz. of soft soap to 4 gallons of water and, for plants under glass, fumigation with nicotine vapour or hydrocyanic acid gas. A second fumigation is necessary to kill the larvæ that were in the egg stage at the time of the first, as this stage is immune from the effects of the fumigation.

*Unprotected Plant-lice*.—Plant-lice are very sensitive to tobacco juice. A solution of 0·1 per cent. of nicotine, say 1 per cent. of strong tobacco juice containing 10 per cent. of nicotine of the French State factories, suffices to obtain a satisfactory result. However, the nature of the lice prevents this liquid from moistening them, and these sprayings only reach a small portion. To remedy this drawback, it suffices to dissolve in the nicotine solution 1 per cent. of soft soap. Laurent advises soft soap and carbonate of soda. In these conditions the liquid at once reaches the pest, which die forthwith. The operation must often be repeated, especially, as is frequently the case, when the lice have made protective shelters by deforming the leaves, as is the case with the gooseberry and peach pest. The soapy and alcoholic solutions (formulæ Nos. 3 and 4) are still better.

Experiments made in the U.S.A. indicate the effectiveness of nicotine dust (sulphur-lead arsenate 90 : 10, with 2 per cent. of nicotine) on apples in the early pink stage for the control of aphids.

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[1] PENTATOMIDES (bugs).—Several species of pentatomides, known vulgarly as *bugs*, live at the expense of the crucifers. Owing to their large number they may cause great damage in cabbage fields by sucking their juice.

[2] CECIDOMYÆ.—Small gnat-like flies, 2—3 metres long, with long slim legs. CECIDOMYA DESTRUCTOR (Hessian fly).—Blackish with red circles on the abdomen. It appears in April. The larvæ attack the base of the stem of wheat without penetrating into the interior; by persistent sucking they end in making small pits in the stem in which they lodge. Atrophy of the stem of the wheat results, and the latter soon breaks.

*Schizoneura lanigera*, Hausm. (woolly aphis).—Nessler's solution (formula No 3) is advised for the destruction of this aphis. According to the researches of Stedman it would follow in an irrefutable manner that the woolly aphis extends its ravages to the underground part of the apple-tree; to completely destroy the aerial colonies the roots must be disinfected at the same time. Gillette has studied the effects of powdered tobacco [? snuff] in this particular instance. It is now regarded just as it is bought as an infallible specific for the destruction of the underground form of this pest. Powdered tobacco mixed with earth is frequently used in nurseries and also for other crops.

*Phylloxera vastatrix*, Planch. (phylloxera of the vine).—Mouillefert found tobacco juice destroyed this aphis.

*Tingis piri*, Fl. (tiger of the pear-tree).—Sajo advises 2 lb. of tobacco juice containing 14·5 per cent. of nicotine in 100 gallons of water as a means of radically destroying the tiger, but care must be taken to direct the jet on the lower surface of the leaves.

*Pulvinaria vitis*, L. (*Coccus vitis*) (vine scale).—Targioni-Tozzetti advises to destroy the mobile larvæ of this cochineal by spraying with tobacco powder or using powders with a nicotine basis. Mohr praises the effects of the following mixture deadly to cochineals in general: Add 25 lb. of soft soap, 20 lb. of ammonia, 20 lb. of oleic acid per 100 gallons of tobacco juice. Guocdenovic records the good effects of a mixture of 1·5 per cent. of tobacco juice and 0·5 per cent. of soft soap against the *Dactylopius vitis* (white cochineal of the vine).

*Thrips hæmorrhoidalis*, Bché. (black thrips of greenhouses or black fly of the gardener).—It infests plants in greenhouses, and under cloche, such as azaleas, camellias, fuschia, and causes them to fade. It may be overcome, according to Decaisne, by powdered tobacco and fumigations. Noel advises to soak the residues from the manufacture of tobacco in a solution of 2 lb. of nitrate of potash in a gallon of water and then dry it and burn it in the hothouse.

*Limithrips tritici* (thrips which ravage onions).—It may be destroyed, according to Webster and Rathay, by a decoction of tobacco.

[Animal and plant-lice are effectively treated by tobacco juice.]

*Phyllocoptus Schlechtendali*, Nal. (browning of the leaves of the pear-tree).—This acarus may be destroyed, according to Sirodot, by tobacco juice marking 1·5° Bé. and sprayed on all the parts of the tree.

Greenhouse *acari* do not stand fumigation (Decaisne) nor spraying with the mixture of ammonia, tobacco juice, soap, and oleic acid to be used against vine scale.

*Tetranychus telarius* (red spider).—Rathay kills this pest with tobacco juice.

*Tetranychus althææ* (Tetranychus which causes the rusting of the leaves of the hop), (Kupferbrand). It is overcome, according to Voss, by preventive treatment. In the autumn the soil is dusted with powdered tobacco [? snuff]. Spraying with tobacco juice has little effect on adult tetranychus living on the plant (Sorauer). Voss' method is preventive. It kills the tetranychus which hibernate under the leaves on the hop fields and prevents the return of the disease.

**Quassia Amara** [true].—Quassia is derived from a Guiana tree, the quassia tree [*Quassia amara*]. The quassia of the shops is the wood of *Picrena excelsa*, belonging to the family of *Simarubiaceæ*. The wood and the roots are sold as chips or lumps (*Lignum quassicæ*). To extract the quassia the chips are macerated for twenty-four hours in water. Insecticides with a quassia basis are prepared thus: (1) Boil on the other hand, 5 lb. of quassia chips in 50 gallons of water; let stand for twenty-four hours and decant the extract; on the other hand, dissolve 5 lb. of soft soap in 50 gallons of water. Mix the two liquids. (2) 7½ lb. of quassia are macerated and 3½ lb. of soap are dissolved in 100 gallons of alcohol. (3) 1½ lb. of quassia are macerated in water, heated to boiling and decanted; after twenty-four hours a solution of 2½ lb. of soft soap is added and the bulk made up to 10 gallons. (4) Dissolve 10 lb. of soft soap in 5 gallons of hot water, add thereto an infusion of 2½ lb. of quassia chips obtained by twelve hours' steeping in 5 gallons of rain water; make up to 40 gallons (Koch's insecticide). (5) Emulsify 5 gallons of petroleum in a solution of 6 lb. of soft soap in 50 gallons of water (see petroleum), and add thereto an extract of 10 lb. of quassia in 50 gallons of water. (6) Add 4 lb. of carbolic acid to a mixture of 5 lb. of quassia extract and 6 lb. of soap in 100 gallons of water.

The following formulas are typical examples of the variation in the amount of ingredients in U. S. Quassine preparations:

| | | No. 1. | No. 2. | No. 3. |
|---|---|---|---|---|
| Quassia chips | pounds | 2·8 | 8 | 9 |
| Whale-oil soap | do. | 1·6 | 6 | 6 |
| Water | gallons | 100 | 100 | 100 |

These formulas are concocted differently by different growers. Some soak the chips 24 hours in a barrel of water and then boil them for 2 hours. Some boil them for 2 hours without previous soaking, and others boil them with the whale-oil soap. Recent U.S. experiments show that quassine used at the rate of 0·4 gram to 2,000 cubic centimetres, or 6½ ounces of 40 per cent. solution to 100 gallons, was almost as effective against the hop aphis and the prune aphis as nicotine sulphate, 0·4 gram to 2,000 cubic centimetres, or 6½ ounces to 100 gallons. The difference is approximately 3 per cent., while quassine 0·4 gram to 1,000 cubic centimetres is fully as effective.

**Properties.**—Quassine, the active principle of *Quassia amara*, is amorphous or crystalline. It has been isolated by Winkler. It is colourless, inodorous, opaque, and inalterable in the air, slightly soluble in water, much more soluble in water charged with salt or organic acids, and in alcohol. To man, quassine is not poisonous, it is toxic, aperient, and stomachic. In doses of 4–10 centigrammes per day, quassine has no injurious effects on man; on the other hand, it is deadly to the lower animals—oxyures, ascarides, etc.

**Action on Plants.**—Plants are not injured by spraying with aqueous extracts of quassia; on the other hand, extracts mixed with soap are injurious to certain plants, especially if soft soap be used and if the dose is superior to 1 per cent. Gleischer prepared the following table on this point for Klein's solution (No. 3, *supra*):—

TABLE LXXXIII.—*Showing the Action of Klein's Solution* (3) *on the Organs of Various Plants.*

| Plants and their Organs. | Action. |
|---|---|
| Shoots and leaves of the apple-tree | Hardly attacked |
| Leaves of the plum | ,, ,, |
| Vine | Unattacked |
| Nasturtium | Greatly damaged |

**Action on Insects.**—No insect can live in boxes made of quassia wood; fly-paper is blotting-paper soaked with a sugared extract of quassia. Quassia insecticides act on soft-skinned, non-protected insects, on their larvae, on caterpillars, plant-lice, and phytotides. Koebele regards quassia extracts as less active than fish-oil emulsions.

**Use.**—*Caterpillars of Fruit Trees.*—Insecticide (5) is recommended by Gilardi as an excellent medium for destroying various caterpillars which infest fruit trees.

*Myzus cerasi.*—A quassia-soft soap spray is recommended by the British Ministry of Agriculture for use against cherry black-fly.

*Cochylis ambiguella*, Hubn. (cochylis of the vine).—Insecticide No. 1 is regarded by Gilardi as sufficient to destroy the caterpillar of the cochylis.

*Unprotected Plant-lice.*—Plant-lice are very sensitive to quassia extracts. Whitehead recommends insecticide, No. 1 against the hop aphis and the wheat aphis; Klein and Fleischer insecticide No. 3 against green aphides and even against the woolly aphis. Mohr the insecticide No. 1 against the aphis of the peach and of the gooseberry, to be used when the leaves begin to uncurl.

*Phylloxera vastatrix*, Pl. (phylloxera of the vine).—Mouillefert regards quassia as inefficient against this louse. In Germany, Schmidt has taken out a patent, D.R.-P. No. 50772, for a mixture to be used to destroy the phylloxera of the vine, the composition of which is methyl alcohol 30 parts, turpentine 10 parts, extract of quassia 3 parts, or methyl alcohol, 60° Tralles, 10 parts, carbonate of potash dissolved in water 1 part, quassia extract 1 part, phosphoric acid, 20° Bé., 1 part.

*Phytoptus ribis*, W.—A liquor made from 4 lb. of quassia chips and 3 lb. soft soap, in 50 gallons of water, used as a spray in the spring and in the autumn as soon as the fall of the leaf, destroys these insects.

*Phytocoris militaris*, Westwood (orchid bug).—Staes has shown that tobacco powder had no action on this bug, but that, on the contrary, a decoction of quassia with soft soap destroyed them.

**Hellebore Root.**—Hellebores, plants of the family *Ranunculaceæ*, contain a bitter substance which imparts to them violently drastic properties and renders them poisonous in large doses. It is chiefly the roots which contain this principle.

**Preparation of the Liquid Insecticides.**—(1) 5 to 7½ lb. of finely pulverised hellebore roots are stirred up in 100 gallons of water; this bouillie is used such as it is without being decanted. (2) The powder obtained by finely pulverising white hellebore roots is diluted with up to 10 parts of flour; at the fall of the dew it is spread on the plants by means of a bellows or through a muslin bag. (3) Make a decoction of

1 lb. of hellebore root and let it stand twenty-four hours. (4) Emulsify 60 fluid oz. of paraffin oil with a solution of 120 oz. of soft soap in 10 gallons of water, then incorporate 40 oz. of hellebore root (Whitehead).

**Action on Insects.**—Hellebore root is a violent poison to insects which gnaw leaves, it acts like arsenical salts and is used in their place.

**Use.**—Insecticides Nos. 1 and 2 appear according to Whitehead and Riley to be specific against :—

*Eriocampa adumbrata*, *Eriocampa cerasi* (the slimy caterpillar, slug-worm).

*Pterenus ribesii*, Scop. (gooseberry saw-fly).

*Cladius pectinicornis*, F., *Emphytus cinctus*, L., *Monostegia rosæ*, H. (rose saw-fly).

*Abraxas grossulariata*, L. (magpie moth).—Emulsion No. 4 is recommended by Whitehead against *Psylla*, *Anthonomus pomorum* and *Schizoneura lanigera* (woolly aphis).

A mixture of 4 to 16 oz. of hellebore (poisonous) powder with 10 gallons of water is recommended by the British Ministry of Agriculture for use against the pear and cherry saw-fly (*Eriocampa limacina*, Cameron). Against caterpillars the quantity of hellebore is increased to 2 lb. and ½ to 1 lb. of soft soap is added.

*House Flies.*—The U.S. Department of Agriculture recommends the systematic destruction of the larvæ of flies by sprinkling manure heaps, waste heaps, and all kinds of soft refuse in which flies may lay their eggs with solutions of hellebore or borax. If the manure is to be used for field or garden fertilisation, the solution of hellebore should be used, as a solution of borax of more than a certain strength might injure the fertilising value of the manure. The report speaks of powdered hellebore as being readily obtainable "in most places at a low price," and specifies a solution formed of ½ lb. of powdered hellebore mixed in 10 gallons of water. This, it states, is sufficient to kill the larvæ in eight bushels of manure. The mixture should be sprinkled carefully over the pile, especial attention being paid to the outer edges.

**Pyrethra.**—The pyrethras, plants which belong to the family of Compositæ, contain an insecticidal principle. Two plants are chiefly used to make pyrethra powder or bug powder; these are *Pyrethra cinerariæfolium*, Treviv., and the *Chrysanthemum coccineium*, Willd. A species originally Caucasian, *Pyrethrum roseum*, contains less active principles. Although cultivated in Asia, insecticidal pyrethra can accommodate themselves to the South of France. Insect powder shipped from Japan is made from ground pyrethrum flowers, usually exported under that name or as "pyrethrum insect powder." The Japanese product largely took the place of the Dalmatian supply during the world-war period. As the seeds from which the plants were originally grown came from Dalmatia, it is probable that this powder is sometimes sold in the United States under the name of "Dalmatian powder," but neither the name "Dalmatian powder" nor that of "Persian insect powder" is ever used in Japan in connection with ground pyrethrum flowers which are produced within the country.

**Preparation of Pyrethra Powder.**—The flower, the sole organ of the plant containing the insecticidal principle, is ground alone. According to certain authors the best powder is made from unexpanded flowers; others say that the flower-bud must be perfectly closed, whilst others assert that the flowers should be collected when the flower is in full bloom. Pyrethra powder is made in America, Great Britain, Japan and Germany. Pyrethra powder is none other than the dried flower suitably and finely pulverized. It is used most often alone, but sometimes it is mixed before use with three times its weight of flour, or with four times its bulk of sulphur to destroy both the altise and the oidium of the vine, or again with cupric sulphosteatite to destroy the altise and the mildew.

Recent researches made on pyrethrum show that the active principle in the flowers of *Chrysanthemum cinerariæfolium* can be extracted in the form of two esters, called pyrethrine I and pyrethrine II. The former is a thick oil containing a monocarboxylic acid and an alcohol, pyrethrolon. Pyrethrine II is a thicker, slow-flowing material containing a dicarboxylic methyl ester acid and the same alcohol, pyrethrolon. Pyrethrine I is the more effective, a dilution of 1 in 10,000 requiring 10–20 minutes to kill cockroaches, *Blattella* (*Blatta*) *germanica*, L., whereas pyrethrine II takes twice the time. These substances are the most powerful insect-poisons known, being approached only by nicotine, which, however, is a dangerous general poison, whereas the pyrethrines do not appear to affect warm-blooded animals. Lice, bugs, midges, bees and butterflies were affected in the same way as cockroaches. Dalmatian insect powder contains 0·3 per cent. of the active oils.

The U.S. Department of Agriculture, in investigating the keeping properties of pyrethra found that: 1. Whole and ground flower heads kept in sealed fruit jars for 150 weeks were not injured. 2. Ground flower heads kept in tightly closed glass containers for 5½ years lost practically all of their effectiveness. 3. Whole flower heads kept in tightly closed glass containers for 5½ years were practically unhurt. 4. Whole flower heads exposed in an open dish in a room for 150 weeks were not injured. 5. Ground flower heads were not injured by an exposure for 34 weeks in an open dish in a room. Their value was materially reduced by an exposure of 136 weeks and they were practically worthless at the end of 150 weeks. 6. Whole and ground flower heads were uninjured by an exposure to the weather of 12 weeks, but an exposure of 21 weeks greatly reduced their efficiency. 7. Powdered flower heads heated at 120° C. for 18 hours were practically uninjured, but a temperature of 130° or 140° C. for the same length of time destroyed practically all of their effectiveness. 8. Ground flower heads were slightly injured by soaking for 24 hours in cold water, and materially injured by soaking for the same length of time in hot water.

**Preparation of Pyrethra Extracts.**—1. *Aqueous Extracts.*—6 lb. of pyrethra powder are treated cold with 10 gallons of water. Maceration lasts twenty-four hours. It is easier to make the extract by aid of heat. The pyrethra powder is first made into a paste by hot water, it is thinned down gradually with boiling water and cooled. Before use this extract is diluted with six to eight times its volume of water without losing its insecticidal properties.

2. *Soap Extract.*—Dissolve 3 lb. soft soap in 1 gallon of hot water; add thereto whilst stirring with a birch-broom 1½ lb. of Dalmatian

pyrethra powder and 9 gallons of cold water. Invented by Dufour of Lausanne, this insecticide is one of the most perfect now existing.

3. *Alcoholic Extract.*—Treat 6 lb. of pyrethra powder with 10 gallons of 80 per cent. alcohol. Dilute before use with 5 parts of water.

4. *Alcoholic and Ammoniacal Extract.*—Mohr mixes in a flask 100 grammes of Dalmatian pyrethra powder, 200–250 grammes of alcohol, 80—100 grammes of commercial ammonia. After some days he adds 1½—2 litres of water, and heats gently for forty-eight hours. [Similar proportions in the same ratio are 1 lb. of pyrethra powder, 2—2½ lb. of alcohol, 0·8—1 lb. of commercial ammonia, and 1½—2 gallons of alcohol.] The liquor is filtered and mixed as follows :—

TABLE LXXXIV.—*Showing Composition of Pyrethra Insecticides.*

|  | No. 1. | No. 2. |
|---|---|---|
| Extract | 3 lb. | 5 lb. |
| White soap | 2½ ,, | 5 ,, |
| Non-calcareous water | 10 gals. | 10 gals. |

Preference must be given to one or other of these insecticides according to the resistance of the insect to be killed.

5. *Cupric Insecticide Bouillie.*—Treat by boiling from five to ten minutes or by maceration for twenty-four hours in the cold, 3 4 lb. of pyrethra powder in 10 gallons of water, and mixing this extract with a cupric bouillie by running it into the concentratred bouillie. This bouillie has the advantage of acting both on the mildew and the altise of the vine simultaneously.

6. *Alcohol and Carbon Disulphide Extract.*—Treat 7 oz. of pyrethra powder by maceration for eight days in a mixture of 7 oz. of ether, 25 oz. of carbon disulphide, and 75 oz. of alcohol, 86° Bé. (all by weight). Filter afterwards (Pratigeon).

7. *Pyrethra-petroleum Emulsion.*—Emulsify petroleum in an aqueous pyrethra extract. This emulsion is recommended by Webber against coccidea.

**Properties.**—Pyrethra powder forms a very fine light powder, the insecticidal principles of which are volatile. Old powders are dead and inert.

**Action on Plants.**—Pyrethra powder has the great advantage over insecticides, such as petroleum, carbolic acid and others, of having no injurious action on the leaves; even the soapy extracts if they do not contain too large a dose of soap are without injurious action on plants.

**Action on Insects.**—The intensity of the action depends on the freshness of the pyrethra powder. The insecticide action of the powder sold under the name of bug powder has been known for a long time. If it be not preserved in a well-closed bottle, its insecticidal power departs; moreover, its action is of very short duration, the active principles being very volatile. Carapaceous insects are generally insensitive to this insecticide; it is not so with soft-skinned insects and larvæ not portected by a hairy down, these succumb readily. The different soapy and alcoholic extracts are much more active owing to the substances which they contain, which moisten the insects touched more perfectly than aqueous extracts.

**Use.**—As powdered pyrethra is in domestic use to treat plants in pots infested by lice and to free them from vermin. The extracts would find an extensive use if they were cheaper and their action less variable according to whether the pyrethra bought is fresh or old.

Against caterpillars, such as those of the magpie moth the British Ministry of Agriculture recommends a spray of 2 lb. of pyrethrum powder, 10 gallons of water and ½ to 1 lb. of soft soap, according as the water is soft or hard.

*Sparrows.*—To poison sparrows, it suffices to place a handful of hellebore powder in 1 quart of water and boil grains of wheat therein. The sparrows eat them without suspicion.

*Rodents.*—Constantin Cesar recommended in 1543 to place in rat holes during great heats (1) a mixture of rye grain, barley-meal, and hellebore, or (2) a paste made by grinding equal parts of bitter almonds and hellebore, and afterwards mixing with barley-meal and oil.

*Leptinotarsa decemlineata* (Colorado beetle).—Alvood found that if the powder is inert against adult insects, it kills 50 per cent. of the larvæ.

*Saperda populnea*, L. (the poplar borer).—To destroy the larvæ of this Coleoptera, Mohr advises to inject his extract No. 1 (p. 409) into their burrows by means of a caoutchouc drill guided by an iron wire. The amount should be such that the liquid flows from the orifice. After a quarter of an hour all the larvæ leave the holes and can be crushed. The same process is used to destroy the caterpillars of *Cossus* and of *Sesia ;* the latter dies in the holes.

*Haltica ampelophaga* (altise of the vine).—Pyrethra is regarded as an excellent medium for getting quit of the altise of the vine, and altises in general, 12—15 per cent. of pyrethra powder with ordinary sulphur or Apt sulphur to overcome simultaneously the oidium and altises. Gervais advises to mix pyrethra powder with "Cupric-sulphosteatite." Two applications suffice to get quit of this minute insect. Pyrethra extract may likewise be added to cupric bouillies. The extract alone is used at 4 per cent. strength. Many observers attest the powerful action of mixtures containing pyrethra. Taschenberg and Montillot advise to kill in a general way all earth lice by using mixtures of pyrethra powder and naphthalene; naphthalene 2 lb., pyrethra powder 1 lb., or pyrethra powder alone.

*Lema melanopus*, syn. *Crioceris melanopa* (crioceris of cereals).—To kill the larvæ of this insect, injurious to grain crops in Hungary, Sajo recommends to spray copiously with aqueous pyrethra extract. This process destroys 75 per cent. Nicotine is regarded as more active.

*Entomoscelis adonisis*,[1] Pall.—Sajo advises 2·5 per cent. pyrethra extract to destroy rapidly the larva of this insect which gnaws the leaf of the beet.

*Cochylis ambignella*, Hubn. (cochylis of the vine).—The soapy extract of pyrethra with 3 per cent. of soap has been recommended by Dufour to kill the caterpillar of this butterfly. The first spraying must be given before flowering, when the caterpillars have just hatched, and the second after flowering. It is one of the best means of killing the red-worm of the vine. Sirodot recommends its application by a spraying machine, with an intermittent jet, which is directed on to the grapes morning and evening in the month of July.

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[1] ENTOMOSCELIS ADONISIS.—The perfect insect and its larvæ gnaw the leaves of radishes and cabbages in Canada.

*Polychrosis* (*Eudemis*) *botrana*, Schiff.—In Swiss experiments carried out on a large scale the insecticides used were: Pyrethrum-soap solution, using 9 parts of soap-pyrethrum to 90 of water; a copper sulphate spray, with the addition of 10 lb. nicotine (15 per cent.) or 15 lb. tobacco decoction (8 per cent. nicotine) per 100 gals. of spray; an arsenical copper sulphate spray, in which 3 lb. Paris green or 10 lb. lead arsenate is added to 100 gals. of spray; 2 parts lime to 1 part of pyrethrum powder; and 95 per cent. of lime with 5 per cent. of calcium carbide. The value of pyrethrum-soap solution against the young larvae of the first generation of *C. ambignella* and the first and second generations of *P. botrana* has been confirmed. The results obtained by the dust mixtures were poor, probably owing to the heavy rains of 1924, and perhaps owing also to lateness in application; experiments with them will be continued. Against the second and third generations of *P. botrana*, pyrethrum and nicotine treatments were found to be best; dust gave poor results, though the lime and calcium carbide seemed more promising than the lime and pyrethrum. The copper sulphate spray with nicotine can also be used after the main calcium carbide seemed more promising than the lime and pyrethrum. flight of the moths, against all generations of both moths. The arsenical copper sulphate spray can be used against the larvae of the first generation of both species, but 15 days at the latest after blossoming all arsenical treatment should be stopped and the copper sulphate spray with nicotine substituted as soon as the main flight is over. The authors are of opinion that winter measures against these moths are too expensive to be worth while; even if they succeeded in killing the majority of the hibernating pupae, under favourable conditions for development, the numbers would soon increase to normal again. The efficiency of different brands of pyrethrum-soap was found to vary a good deal, and even that of the same brand varied from one time to another. Powder made from flowers of the second crop was quite effective. The experiments showed that the stalks of pyrethrum contain active insecticidal principles, and should be used. Good results were obtained whether the powder was made from flowers only, from the stalks only, or from the whole plant as gathered by the scythe and chopped in a chaff-cutter. The usual process is to mix the extract from 1 part by weight of flowers or stalks with 6 parts of concentrated soap solution. By increasing the quantity of stalks used for extraction to 2 or even 3 parts to 6 parts of soap solution the insecticidal value was no greater. Alcohol used to be the only medium for extraction, but recently a number of other media have been tried, remarkable results being obtained in particular with petroleum ether. The further addition of a certain quantity of alcohol or soft soap did not increase the insecticidal power. It has generally been thought that the flower buds of *Chrysanthemum* (*Pyrethrum*) *cinerariæfolium* are stronger in insecticidal properties than the full-blown flowers (and they are generally more expensive in consequence), but the present experiments indicate that the contrary is the case; moreover, as the flowering period progresses the active principles increase in both flowers and stalks. It seemed also that, at least in alcoholic extracts, the quantity of alcohol used in treating the pyrethrum powder may also influence the insecticidal substances; the greater the quantity of alcohol used, the less power there was in the pyrethrum-soap solution. Attempts have been made to combine pyrethrum-soap solution with Bordeaux or Burgundy sprays used against mildew, but this is not recommended, as the insecticidal value of the pyrethrum-soap is distinctly lessened.

*Carpocapsa pomonella*, L. (codlin moth).—Mohr recommends his No. 2 extract (p. 409) applied before flowering, to destroy the young caterpillars of this pyralis.

*Eriocampa adumbrata* (slimy caterpillar, slug-worm).—Dufour's soapy extract of pyrethra (p. 409) gives good results in the destruction of the slimy caterpillar (Siedler).

*Hylotoma rosarum*, Fabr. (hylotome of the rose).—Mohr recommends his No. 1 extract (p. 408) against the false caterpillar of this saw-fly. Taschenberg reports the good results from a mixture of 66 per cent. of pyrethra powder and 33 per cent. of naphthalene against the larvæ of saw-flies in general.

*Athalia spinarum*[1] (*Athalia centifolia*), [the turnip saw-fly, black caterpillar, blacks, canker, black palmer, nigger or black grub], Fabr.—This saw-fly, the larvæ of which ravage the leaves of beets, may be destroyed, according to Burki, by an aqueous mixture of 4 per cent. of soft soap and 1 per cent. of extract of pyrethra powder.

*Lopus sulcatus*, may be destroyed, according to Pratigeon, by the alcoholic and carbon disulphide extracts of pyrethra referred to above.

*Diplosis rosivora*.—This rose-fly gnaws the shoots of the rose-bush. Chittenden recommends pyrethra powder to combat it.

*Diplosis violicola*, Coq.—It is killed in the same way.

*Ants*.—Taschenberg recommends killing them with a mixture of pyrethra powder and naphthalene. Mohr advises his extract (p. 408) at the rate of 30—35 fluid oz., diluted with 250 fluid oz. of water and poured on the ant nest in the morning before the ants come out. In light soils and with large ant nests, it is necessary to pour 1—2 litres of this liquor, say 1 to 2 quarts.

*Schizoneura lanigera*, Hausm. (woolly aphis).—Grossbauer recommends to destroy this parasite with a mixture of soft soap 7½ lb., pyrethra powder 2½ lb., in 100 gallons of water. Muller found this liquor less energetic than Nessler's insecticide at $\frac{1}{10}$.

*Naked Plant-lice*.—According to the experiments of Fleischer, the soapy extract kills them easily. Hotter recommends the powder, because it can penetrate into the twisted, rolled, and deformed leaves which serve as a refuge to many plant-lice and surely reach the latter.

*Psyllas* and *Phytoptides* (gall mites) are destroyed in the same way.

*Slugs*.—Mohr recommends his extract No. 2 (p. 408) to kill slugs.

**Derris Root**.—Various species of *Deguelia* (*Derris*) occurring in the Philippines have been tested for their insecticidal properties. In experiments with the commercial extract of 16 per cent. concentration, a dilution of 1 to 500 killed 13 per cent. of *Aphis nerii*, Boy., and 50 per cent. of *Myzus* (*Rhopalosiphum*) *persicæ*, Sulz. (green peach aphid). Dilutions of 1 to 300 killed 68 per cent. of *M. persicæ* and 25 per cent. of *Tetranychus telarius*, L. (red spider). Undiluted powdered root killed all aphids in 8 hours, and 98 per cent. of the larvæ of the nymphalid, *Euphydryas chalcedona*, Dbl. & Hew., when dusted on the leaves on which they were feeding. It is therefore concluded that the active principle of "derris" is both a stomach and respiratory or tracheal poison. The fumigating action of the commercial extract was close to that of the toxicity curve for spraying. A comparative test on pyridine as a fumigant gave an efficiency of 3·8 per cent.

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[1] ATHALIA SPINARUM. Tenthredo (saw-fly) of the turnip.—The larva of this saw-fly attacks the turnip; it gnaws the parenchyma of the leaves.

A spray containing 1 lb. derris, 10 gals. water and 5 oz. soft soap is effective against Aphids infesting tobacco in Sumatra. The derris roots, which may be dry or fresh, are cut into small pieces, placed in a little water and then pounded into a paste, which is diluted with a gallon of water and left standing overnight in a wooden vat; an iron container must not be used. The dregs are then pressed, and all the fluid is strained through a cotton cloth. The resultant concentrate is a milk-white solution, which keeps for a few days only. It is diluted with 9 parts water for spraying. About 16 gals. of solution are needed for 1,000 tobacco plants that have been 25—30 days in the field. Twice this quantity is needed for full-grown plants. If derris roots are to be stored, they must be kept dry.

**Strychnine.**—Strychnine is an alkaloid which is contained in certain plants such as the nux vomica tree, which yields nux vomica, and the walnut-tree.

**Use.**—*Spilographa cerasi*, F. (cherry-tree fly).—Water the soil around the trees after the fall of all the wormy cherries with a hot decoction of walnut leaves that kills the grubs buried at a slight depth in the soil.

*Plant-lice.*—Kasebier recommends the following liquor to get quit of these lice; Make an extract of rasped nux vomica nuts by passing them three to four times into hot water, then letting them macerate some hours. To preserve this extract, $\frac{1}{10}$ per cent. of denatured alcohol (meth. spirit) is added to it when about to be used; to strengthen its action 1 per cent. of "sapocarbol" is added to it. No insect, it would appear, frequents a tree sprayed with this liquid insecticide.

*Phylloxera vastatrix.* Planch. (phylloxera of the vine).—Syringing with strychnine solutions (Mourgue's process) had no more effect on this louse than an infusion of $\frac{1}{2}$ lb. of walnut leaves in a gallon of water (Chevalier's process), or of $\frac{1}{4}$ lb. of walnut leaves in a gallon of water (Panet's process).

*Peach and Gooseberry Aphis* (*Aphis persicæ*).—An infusion of nut leaves collected in autumn destroys these plant lice, especially when it is strengthened by a little soap. Mohr advises to spray as soon as the leaves begin to curl and twist; he sprays twice.

*Sparrows.*—Gramivorous birds may be prevented from devouring corn-seed by dipping the latter into a bath containing strychnine; dissolve 10—15 grammes (say $\frac{1}{3}$ to $\frac{1}{2}$ oz.) of strychnine in the water required to cover entirely 1 kilogramme (2·2 lb.) of seed; steep the grain for two hours, stirring occasionally, then withdraw it and dry it. Kruger remarks that if the birds devour it the first day none reappear the following days.

*Talpa europea* (mole).—To destroy moles it suffices to cut up earthworms into pieces and to roll them in nux vomica powder, and to place them in their burrows.

*Rodents.*—It is advised to poison wheat by strychnine, and to place it in pipes in proximity to the burrows of the rodents. The pipes prevent birds from being poisoned.

**Delphinium** (larkspur).—The extract from the stems, leaves, and seeds of the larkspurs, especially that from the seeds of *Delphinium grandiflorum* and *Delphinium ajacis*, is recommended for the destruction of insects. Powdered larkspur seeds are used in medicine to destroy vermin in the head, and to cure skin diseases; extract of larkspur taken internally is drastic, emetic, aperient, diuretic, and vermifuge. Laboulbene advises larkspur extract to destroy grey-worm, the caterpillar of *Agrotis segetum*, L. The young plants must be copiously watered with this extract.

**Glue.**—Glue made from animal matter may be used to overcome the diseases of plants and animals.

**Use.**—*Peronospora viticola*, de By. (mildew of the vine).—Vesque asserts that solutions of glue cure the vine, but the treatment injures the development of the grape.

*Schizoneura lanigera*, Hausm. (woolly aphis).—Del Quercio declares that an excellent method of destroying this louse consists in coating the colonies with a mixture of 1½ lb. of glue and 3 gallons of tar.

**Catechu or Cutch.**—This astringent substance, extracted from a species of Indian acacia, stops, according to Vesque, the development of the oidium.

**Rose Laurel.**—The infusions of this plant of the family of the Apocynaceæ are used in medicine against scab. According to Debray the rose laurel is macerated, in Algeria, for several days and the putrefied liquid used to destroy insects, chiefly the mole-cricket.

**Aloes.**—Aloes is the resinous juice, extracted from the leaves of several species of aloe. It is bitter and nauseous. It is used as a tonic, purgative, and drastic. In Tunis there is added to Bordeaux bouillie, intended to kill the *Peronospora*, 1—1·3 lb. of aloes per 100 gallons of bouillie, so as to destroy altises simultaneously.

THE END

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